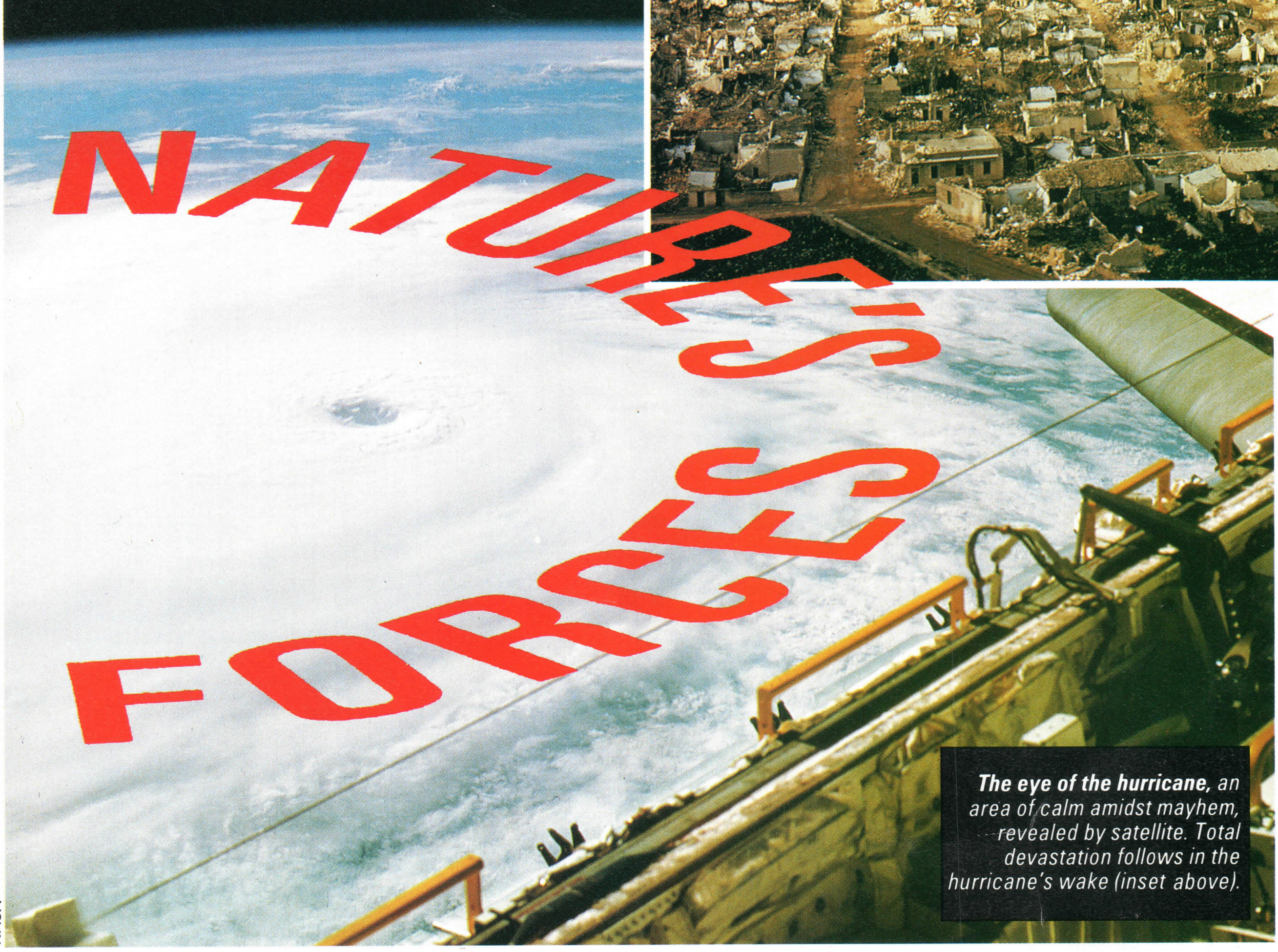
- KILLER WINDS
- LIGHTNING STRIKES
- BURIED BY SNOW

# NATURE'S FORCES

Frank Lane Picture Agency



NASA

**The eye of the hurricane,** an area of calm amidst mayhem, revealed by satellite. Total devastation follows in the hurricane's wake (inset above).

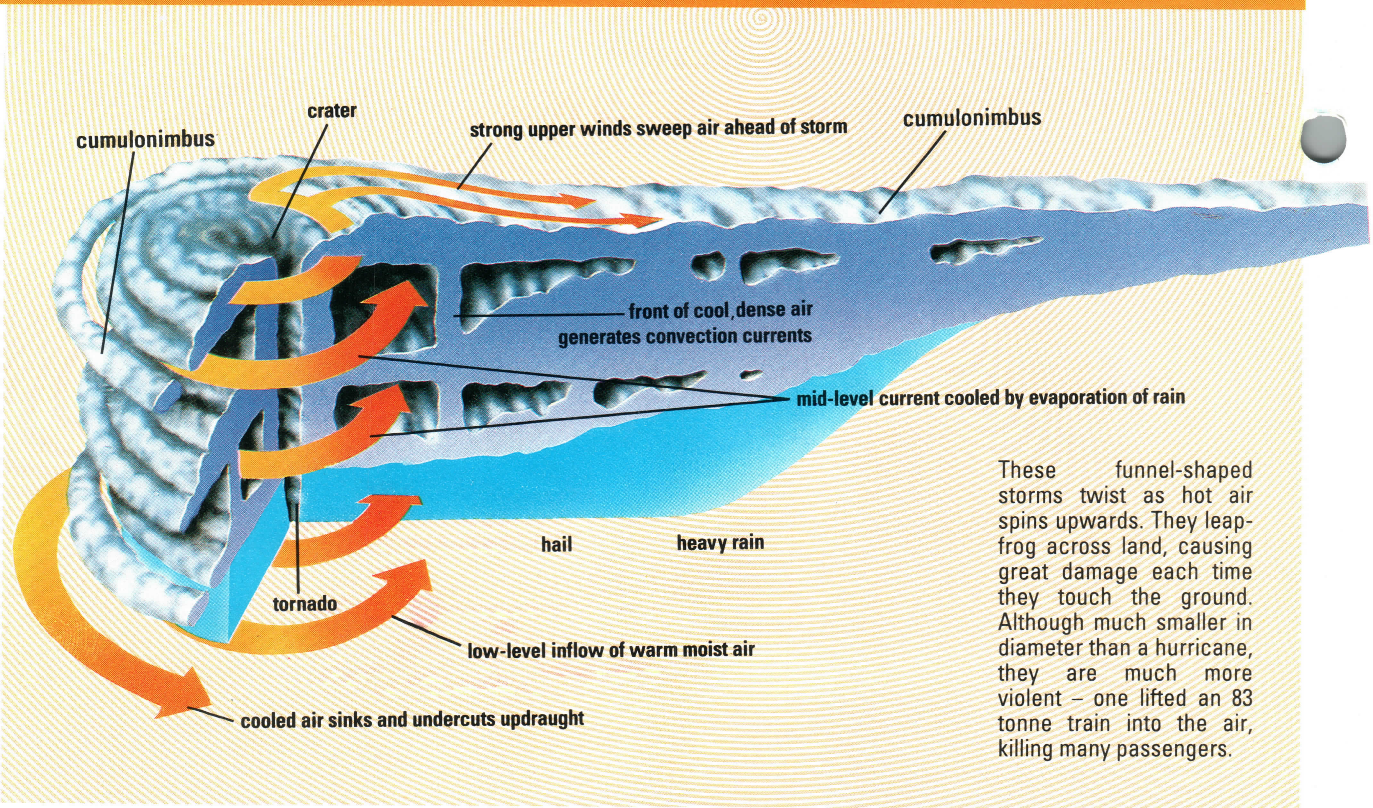
Frank Lane Picture Agency

**Swirling from the clouds** to the ground, tornadoes can travel at speeds of 70 km/h. Although smaller than hurricanes, they wreak just as much havoc.

**LIGHT WINDS, RAIN OR SNOW are the least of the weather's tricks. When it feels in the mood, it can blow you off your feet, hit you on the head with a huge hailstone, then finish you off with a massive electrical jolt from a lightning bolt.**

The destructive power of certain types of weather is enormous. For instance, the storms that develop in the tropics can wreak widespread devastation. When the wind speed of tropical storms gets to more than 118 km/h, these tropical cyclones are given names. In the Caribbean they are called hurricanes; in the Far East, typhoons; in India, cyclones: in the Philippines, tropical cyclones: and in northern Australia, willy-willies or cyclones.

This very violent type of tropical cyclone can only develop in a zone about 5–15° each side of the equator, where there is a great deal of warming energy from the Sun and the temperature of the sea




These funnel-shaped storms twist as hot air spins upwards. They leap-frog across land, causing great damage each time they touch the ground. Although much smaller in diameter than a hurricane, they are much more violent – one lifted an 83 tonne train into the air, killing many passengers.

Janos Marffy

John Cleare/Mountain Camera

***Blizzards strike** without warning, making roads impassable and cutting off communications. Heavy snow, blown by strong winds, can even bury houses and vehicles.*

water is higher than 27°C. Once the cyclone has moved out of the tropical zone, it either dies out at latitudes 40° away from the equator or dissipates its energy over land, where it cannot be fuelled by rising hot moist air.

## Untamed violence

In the Bay of Bengal, in November 1970, a cyclone caused such destruction in Bangladesh that about 250,000 people died. In fact, that part of the world has the dubious record of the most fatal tropical cyclone ever – 300,000 people were drowned in 1737.

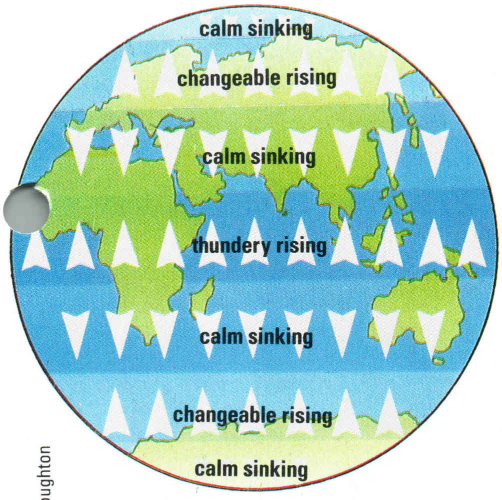
In October 1987, south-east England had hurricane-force winds with loss of life and destruction of property. This was not a tropical storm a long way from home, but an exceptionally violent depression – a most unusual event so far from the dangerous air of the equator.

Tornadoes are much smaller than hurricanes, but despite being on average only a hundred metres wide – compared with the total hurricane system size of 500km – they are much more vicious. Tornadoes only form over land and most happen in the USA, with some in Australia, South America, Europe and southern Africa. The wind speed in tornadoes is enough to flatten everything in their path. They usually move across land at about 70km/h and travel distances of 16–64km. Their wind speed is so great that it can only be estimated.

A tornado forms in large cumulonimbus (thunderstorm) clouds when severe storms are taking place – fast-moving humid winds blowing in opposite directions within these large clouds meet and spiral round each other, sucking in air as they go. As it develops, it looks like a whirling, funnel-shaped

Pertti Luova/Met O

***Encased in ice,** this Greek ship was a casualty of a storm in the Baltic sea in January 1979. As the ship ploughed through the swirling ocean, its bow spread waves high in the air. The water spattered down on to the deck and – in temperatures of almost minus 20°C – quickly froze.*




John Houghton

***Air pressure zones:*** *warm tropical air rises all the way to the top of the troposphere, then moves off towards the poles. The cold air at the poles sinks and moves down towards the equator. In between there are zones of rising and sinking air. When the air is cold and sinking, the weather is dry and settled. When air is rising, however, the weather is disturbed as the rising air cools, expands and condenses into heavy clouds, often bringing thundery weather.*

***Dust devils*** *occur in hot desert areas as a result of spirals of warm air rising off the baked earth and sweeping up dust into a column-like shape. They can reach a height of 60 metres and last only a few minutes. Sandstorms (below) can whip sand up as high as 3,000 metres and can strip paint off cars.*

Frank Lane Picture Agency

Sabine Weiss/SPL

## THE BEAUFORT SCALE

Storm warnings on the radio use the Beaufort Scale. The force goes from 0 to 12: each has its own description, minimum wind speed and effects.

| Force | Strength | Speed (km/h) | Effects |
|---|---|---|---|
| 0 | Calm | 0 | Smoke rises vertically |
| 1 | Light air | 1+ | Smoke drifts slowly |
| 2 | Light breeze | 6+ | Leaves rustle |
| 3 | Gentle breeze | 12+ | Twigs move, flags unfurl |
| 4 | Moderate breeze | 20+ | Dust blows around |
| 5 | Fresh breeze | 30+ | Small trees move |
| 6 | Strong breeze | 40+ | Large branches sway |
| 7 | Near gale | 51+ | Trees sway; difficult to walk into wind |
| 8 | Gale | 62+ | Twigs break off trees; walking is hard |
| 9 | Strong gale | 75+ | Roof tiles and branches blow down |
| 10 | Storm | 88+ | Trees uproot; damage to buildings |
| 11 | Violent storm | 102+ | Widespread damage |
| 12 | Hurricane | 120+ | Large scale devastation |

elephant's trunk stretching down from the cloud to the ground. Rain comes before the wind and rain and hail follow it.

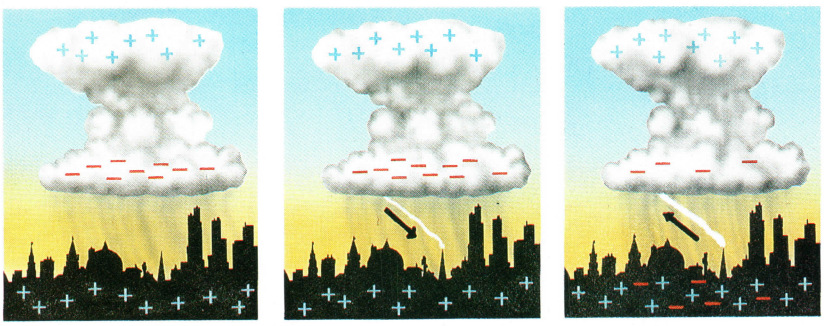
There is a strong upward air current in the middle of a tornado, which sucks up things in its path – leading to some bizarre happenings. Any house or building below the tornado 'explodes' because of the intense pressure difference. Trains have been lifted tens of metres up in the air before being dashed to the ground. The most destructive tornado happened in March 1925, in Missouri, USA, when a tornado 274 metres in diameter swept across the land, killing 700 people and laying waste everything in its path.

The only way to survive a tornado in times gone by was to get into a storm cellar under a house – the superstructure would probably be blown away – or to look where the tornado was going and run away at right angles from its path. This is still the best policy if you are caught out in the open with a tornado bearing down. Modern reinforced concrete buildings are strong enough to withstand the wind, but watch out for flying glass.

## Hail and snow

When the air is cold enough, snow falls instead of rain. Most rain starts off its life as snow or ice crystals way up in the tall clouds where the temperature is low. As the crystals come down, they melt and raindrops form. When the air temperature is low enough, the snowflakes

## THUNDER AND LIGHTNING



Electrical charges build up in the cloud: positive charges at the top, negative ones at the bottom. A leader stroke discharges the negative charge in the cloud into the positively charged earth. A return stroke then flashes up from the ground, heating the air, which expands with a thunderous bang.

Janos Marffy

J.G.Golden/SPL

**Waterspouts are whirlwinds** *extending down from cumulonimbus clouds. They form over seas and lakes, mainly in tropical regions. They churn up the water into a spiral that can be anything from a few metres high to a few hundred metres high and last for about 30 minutes. The most spectacular waterspout ever recorded rose over 1,500 metres and measured over 30 metres across.*

– formed by the gradual crystallizing of tiny water droplets on to microscopic ice crystals that increase in size – can fall all the way to the ground when the updraughts in the cloud are no longer able to support them.

Hailstones are another menace from cumulonimbus clouds. They are formed when raindrops are subjected to forceful updraughts and are taken up and down several times through the freezing layers of a tall cloud. Each time they go up, more water freezes on to them until they are too heavy for the cloud and they fall out. When they fall they can be as small as grains of rice, and can do damage to crops and break windows. In rare cases, they can be as large as apples and extremely dangerous. The largest hailstone recorded fell at Coffeyville, Kansas, USA, on 3 September 1970. It weighed 0.75 kg and was 14cm across.

## Thunder and lightning

If you are caught out in lightning, do not shelter under a tree, get away from metal poles such as electricity pylons and do not stand up or lie down – crouching is better. Get into a car if possible (it's safe); if you are inside a building, stay away from the walls.

How a thunder cloud – a tall cumulonimbus, typically with an anvil-shaped head – builds up the huge electrical charge necessary for a lightning bolt is not fully understood. Ultimately, however, the power comes from the upwelling of warm moist air into cooler air. As moisture condenses out, it gives off heat and water droplets gain kinetic energy as they fall.

The falling and rising of small frozen water particles, ice particles and water droplets seems to create sections of the cloud that are negatively and positively charged. When the difference in charge between the negative and the positive sections of the cloud is great enough, the charge is equalized by a bolt of lightning (a giant spark) linking the oppositely charged areas. Most lightning occurs within clouds (where it cannot be seen) but it also goes from the earth to the cloud (where it is easily visible).

Contrary to what seems to happen, the lightning actually strikes up. There is a small down stroke, called the leader stroke, that acts as a guide for the main stroke. Following the track of the guide stroke, the main return stroke shoots up to equalize the charge between the earth and that found in the lower parts of the cloud.

The temperature within a flash of lightning is around 30,000°C. This is enough to heat the air up so much that it expands explosively, creating the bang that is heard after the bolt.

NASA/SPL

**This thundercloud,** *illuminated by a flash of lightning, was photographed by the Space Shuttle* Discovery. *Most lightning is not usually seen.*

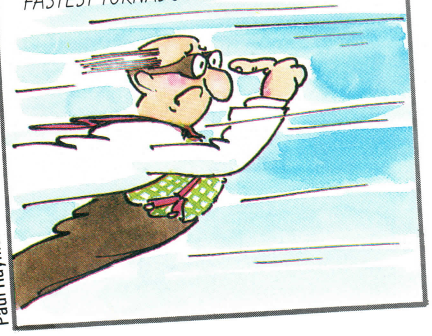
Telegraph Colour Library

**Flashes of lightning** *occur about 6,000 times every minute throughout the world. The flashes travel from clouds to the ground, taking the easiest route possible, often a tall tree or high building – the Empire State Building, in New York, is hit about 500 times each year.*

### Just amazing!

**HIGH-SPEED TRAVELLER**

NO ONE HAS YET MANAGED TO MEASURE THE SPEED OF THE WIND INSIDE A TORNADO – IT'S SO FAST IT DESTROYS THE EQUIPMENT. ESTIMATES PUT THE FASTEST TORNADO AT 725–805 KM/H.



Paul Raymonde

SUN POWER   AIR CURRENTS   CORIOLIS EFFECT

# UNDERSTANDING WEATHER

NASA

**A rainbow-like sunrise** *over the sea, as seen from the Space Shuttle. Uneven heating of the Earth by the Sun, combined with the effects of the Earth's spin, produce complex, swirling air currents. These are clearly displayed in the cloud patterns pictured from space (inset above).*

**BESIDES KEEPING US WARM, the Sun also supplies the energy to drive the Earth's powerful and complicated weather systems. Wind, rain, snow, hail, fog, frost, heat and cold are the ground-level effects of the Sun's heat on our planet's air, water and land at different latitudes.**

The Sun radiates colossal amounts of energy. A great deal of this radiation is visible light. The Sun also pours out other types of electromagnetic radiation, such as ultraviolet rays, radio waves and x-rays. When this radiation hits the Earth's outer atmosphere, it has the power of about 1 kW per square metre. If perfectly collected, the solar radiation falling on a square with sides of 1 metre would boil the water in a 1.7 litre kettle in about ten minutes. The total power reaching the Earth from the Sun is about 100 million million kW. That is more than one hundred thousand times the power produced by all the power stations of the world.

Nearly half of this radiation is either absorbed by the atmosphere or reflected by it back into space. When the radiation that reaches ground level hits land, sea, a tree, building, sunbather or whatever, it is absorbed and changed into the infra-red (heat) radiation that we feel.

When the Sun is directly overhead, as in the tropics, on average each square metre receives about half a kilowatt – enough to power about eight reading-lamp light bulbs. Closer to the poles, where the Sun is shining at an angle to the surface, the Earth receives only about one third as much energy on average.

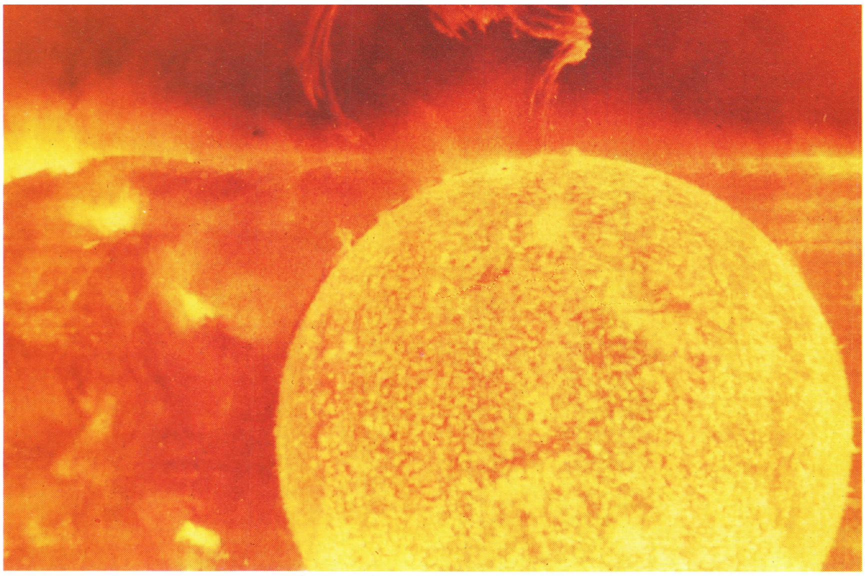
## Balancing heat

If there were no winds, the poles would get very much colder and the equator would get incredibly hot.

Fortunately, the winds carry hot air away from the tropics and cold air away from the poles. How the winds come to blow is the key to understanding the weather.

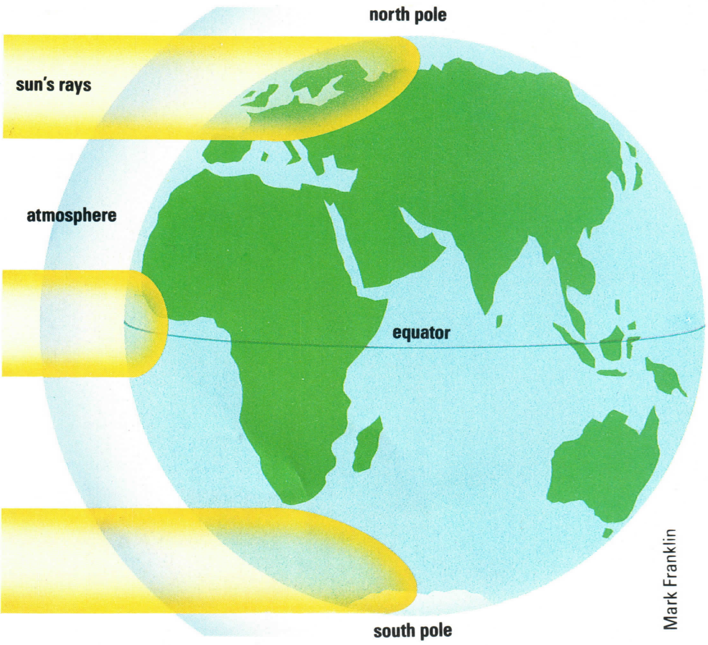
## The troposphere

Almost all the activity happens in the bottom layer of the atmosphere, which is called the troposphere. This is about 18 km deep over the equator and 8 km deep over the poles. In the troposphere, the air is swirling about and this is where most of the heat redistribution takes place. The atmosphere is held down to the Earth by the force of gravity, and the weight of all the air makes up atmospheric pressure.



Telegraph Colour Library

***Blazing hydrogen** prominences shoot out from the Sun as it generates enormous amounts of energy. Some of this energy reaches the Earth and powers our weather systems.*




Mark Franklin

***The Sun's rays** that reach the polar regions travel further through the atmosphere; they also spread out over a larger area of land. This is why the heating effect at the poles is much less than at the equator.*

The first stage of heat redistribution occurs when the air near the equator heats up. Air expands and becomes less dense when it heats up and so it rises. This leaves a reduced pressure on the surface of the Earth below. As a result, cooler air from nearer the poles is sucked in to replace the air that has risen. This movement of air is felt as wind.

The large volumes of air that rise from the areas around the equator eventually reach the top of the troposphere. They then move towards the poles, becoming cooler all the time. Meanwhile, the cool air arriving near the equator heats up and starts to rise.

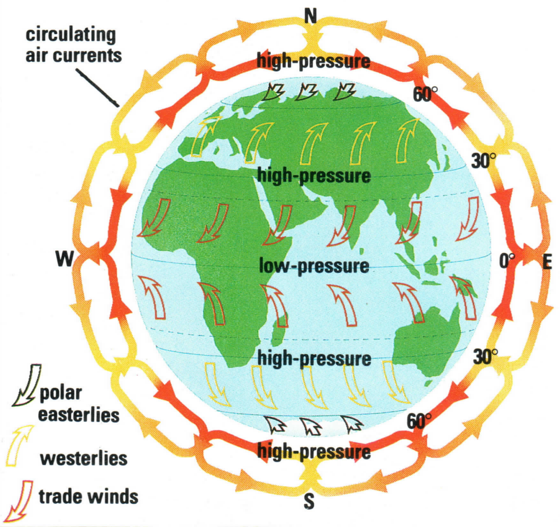
In the tropics, warm air rises in a band extending about 10° either side of the equator. After moving away from the equator, this air descends around latitudes 30° north and south of the equator. The cool air replacing the warm air does not come directly from the north and south, as the rotation of the Earth deflects the winds. This is called the Coriolis effect.

## Wind belts

When the Coriolis effect acts on the cool air approaching the equator, it gives rise to the winds known as the north-east and south-east trades. The air that descends around 30° north and south of the equator causes regions of high pressure. Some of this air returns to the equator, while some moves towards the poles. The latter gives rise to winds which, because of the Coriolis effect, blow from the south-west and north-west. These winds are known as the westerlies.

In the northern polar region, cold winds blow from the north-east: similar winds blow from the south-east in the southern polar region. These are the polar easterlies.

### WHERE THE WINDS BLOW



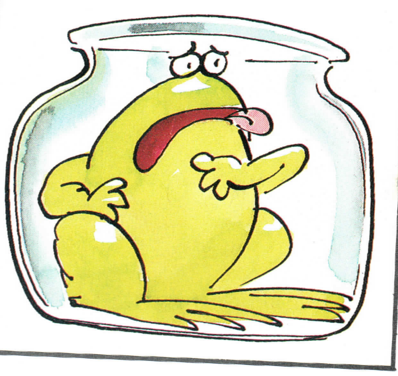

Circulating air currents in the atmosphere produce winds over the Earth's surface. As the Earth spins, the equator and the air above it move round fastest of all. Because of differences in spin speed, air moving towards the equator is turning too slowly towards the east to keep up with the Earth's spin there – so this air appears to be deflected towards the west. Air moving away from the equator is moving faster than required to keep up with the Earth's spin nearer the poles, so it appears to be deflected towards the east.

Mark Franklin

### Just amazing!

**CROAK . . . CROAK . . .**

A STRANGE KIND OF BAROMETER WAS ONCE POPULAR IN GERMANY. A LIVE FROG, KEPT IN A JAR, WOULD CROAK WHEN THE AIR PRESSURE DROPPED.



Paul Raymonde

# elements in action

Richard Howes/Meteorological Office

AIR MASSES

DEPRESSIONS

CLOUDS

**ON A GLOBAL SCALE, THE weather is a giant heat redistribution machine powered by energy from the Sun. The resulting winds and air masses have different temperatures and humidity. Where they meet, they form weather systems, such as depressions and anticyclones.**

Air masses are very large quantities of air that have approximately the same temperature and humidity throughout. They are created over sea (maritime), large areas of land (continental) and over the poles (arctic and antarctic). These air masses are further broken down into warm (tropical) and cold (polar) types. So a polar continental mass would be one made up of a uniform mass of cold air formed over a large land area, while a tropical maritime mass would be one made up of warm air formed over an ocean.

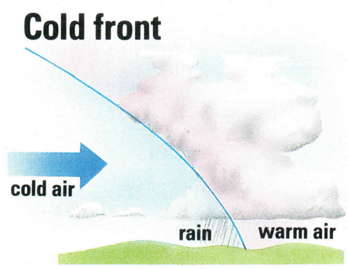
Typically, air masses formed over oceans contain more water vapour than those formed over continents. Warm air masses also contain more water vapour than cold air masses. Thus a tropical maritime air mass has warm humid air, while a continental polar mass has cold dry air. Polar air masses also create higher pressure beneath them as the cold air is denser. Tropical air masses create lower pressure beneath them because the warm air is less dense.

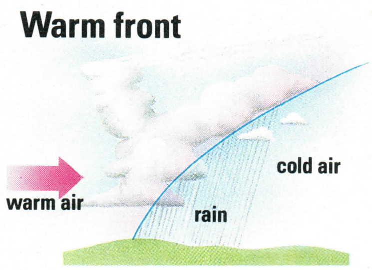
Air masses are pushed or dragged along by the winds. As they are

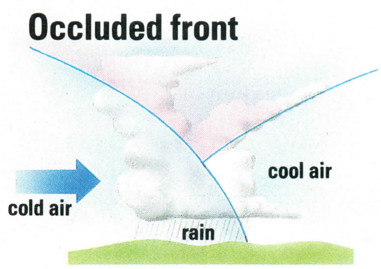
***Alternate layers** of moist and dry air, forming over a mountain range, produce the lenticular (lens-shaped) cloud formation known as altocumulus lenticularis. This type of layered formation is also known as a 'pile of plates'.*

## FRONTS – AIR STREAM BOUNDARIES

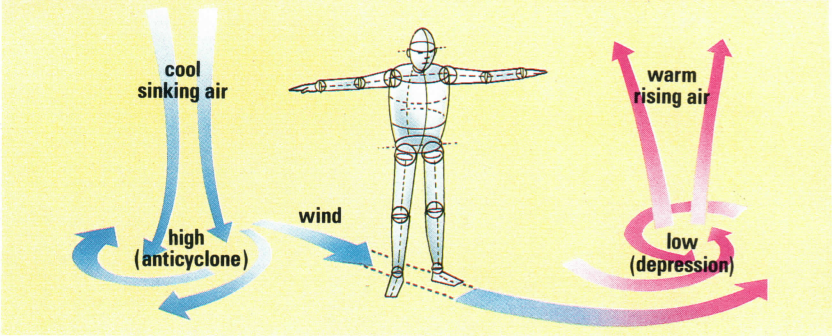
At a cold front, advancing cold air cools a mass of warm air, forming clouds. These typically produce a zone of heavy rain about 80 km wide, followed by a 320 km zone of showers. At a warm front, advancing warm air cools as it rides up and over a cold air mass. The resulting clouds typically give a 320 km zone of rain or snow. When a cold front overtakes a warm front, clouds form in the occluded (cut-off) warm air, giving widespread rain.




Chris Forsey




Chris Forsey

The pressure difference between a high-pressure zone (anticyclone) and a low-pressure zone (depression) causes a wind to blow between them. The Earth's spin makes the wind spiral out from the anticyclone and into the depression. In the northern hemisphere, if your back is to the wind, the depression is always to your left; in the southern hemisphere, where the winds are reversed, it is always to your right.

***A snow shower** sweeps across the Antarctic mountains, driven by the cold winds that blow from the South Pole and curve to the west.*

Kim Westerskov/Oxford Scientific Films

GSF Picture Library

***Clouds settle** in an inversion layer if the air temperature increases with height. They cannot rise any further as the air above them is less dense.*

moved, they take on some of the character of the surfaces over which they travel.

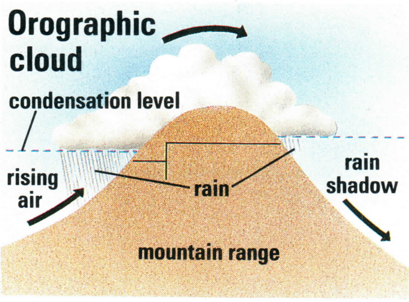
The cold air masses from the higher latitudes are continually moving down towards the lower latitudes. Meanwhile, the tropical masses are moving up from the middle latitudes. The junctions between different air masses are called fronts. The fronts that mark the boundaries between the polar air masses and the tropical air masses are called polar fronts. These regions of contact are where unsettled weather occurs.

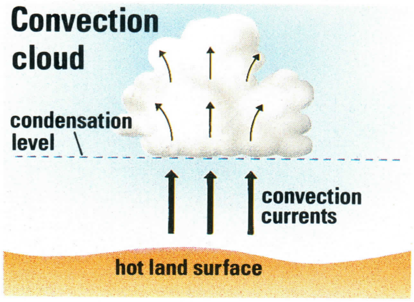
Unsettled weather with stormy winds and rain is brought about by the depressions, or low-pressure regions, that the weather forecasters talk about on TV. These are formed when a tropical air mass bulges into a polar air mass, thus buckling the polar front. The warm tropical air mass, being less dense, rises over the cooler, denser polar air. This rising air causes the air pressure to be reduced under the bulge. The cold dense air races towards the area of lower pressure and, because of the Earth's spin, begins to spiral around it. The spin of the Earth on its axis makes the cold air move anticlockwise in the northern hemisphere and clockwise in the southern hemisphere.

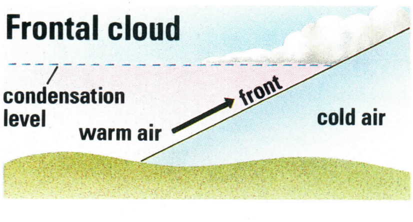
## Changing fronts

As the front of warm air continues to ride up and over the cold air, the pressure drop is greatest immediately below the advancing tip of the warm front. This marks the middle of the depression. Meanwhile, the cold air front swings around behind the warm air bulge, undercutting it.

In time, the cold front catches up with the warm front and cuts off the bulge of warm air above it from the main part of the tropical air




Chris Forsey

***Orographic (mountain) cloud** forms when moist air is forced up the side of a mountain. The cloud produces rain or snow on the windward side, while the sheltered side is relatively dry. Convection cloud forms when warm air rises from a hot land surface or when cold air crosses a relatively warm sea. Frontal cloud forms when warm air rises above cold air at a warm or cold front.*


Roger Evans/SPL

## RAINBOWS

Rainbows form when raindrops split sunlight into bands of colour. In a clearly formed rainbow, seven distinct bands of colour can be seen: red, orange, yellow, green, blue, indigo and violet. Sun light consists of a mixture of different coloured rays and each colour is deflected through a different angle by the rain drops. Therefore rays of a particular colour reach us from only a small group of raindrops. People in different positions see the rainbow in different places, though it is always on the same side of the sky to the Sun.

mass. When this happens, what is known as an occluded (closed-off) front is formed, and the air pressure below starts to rise. The isolated region of warm air gives up its heat to the cold air and mixes with it, so the pressure below rises again.

The opposite of a depression is a high-pressure region, or anti-cyclone. These come about in areas where the air is descending. Descending air warms up and tends to absorb water droplets — so it removes any clouds from the sky. Areas of high pressure usually produce stable weather with clear skies, leading to hot sunny days in summer and cold days with hard frosts in winter.

## How clouds form

Water vapour is an invisible gas and there is one essential rule about how much water vapour air can carry. The warmer the air, the more water vapour it can hold. When warm, moist air cools, it sometimes reaches a point, known as the dew point, where it can no longer hold all its water vapour. Some condenses out into tiny water droplets, which form clouds, mist or fog.

You can see temporary clouds form when you boil a kettle of water. Close to the spout, you can see a clear zone of water vapour; further away, the water vapour cools and condenses to form the clouds of water droplets that we know as steam.

## Rain and snow

A depression usually brings rain because the advancing warm air cools when it meets cold air. As it cools, its ability to hold water vapour decreases. So some of the water condenses out of the cooling air and forms either tiny water droplets or tiny ice crystals. These are seen as clouds.

The water droplets or ice crystals eventually bump into each other and join together. When they are too big to be held up by the air currents in the clouds, the droplets or crystals fall out as rain or snow. Sometimes the raindrops become frozen and fall as hailstones.

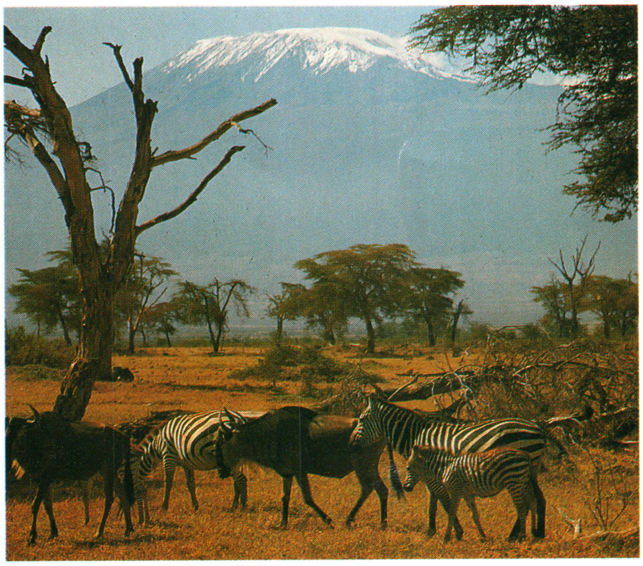
Clouds are formed in a similar way when advancing cold air forces warm air upwards. Also, in an occluded front, the region of warm air loses heat to the cool air below, and vapour condenses as clouds.

### Just amazing!

**WET . . . WET . . . WET**

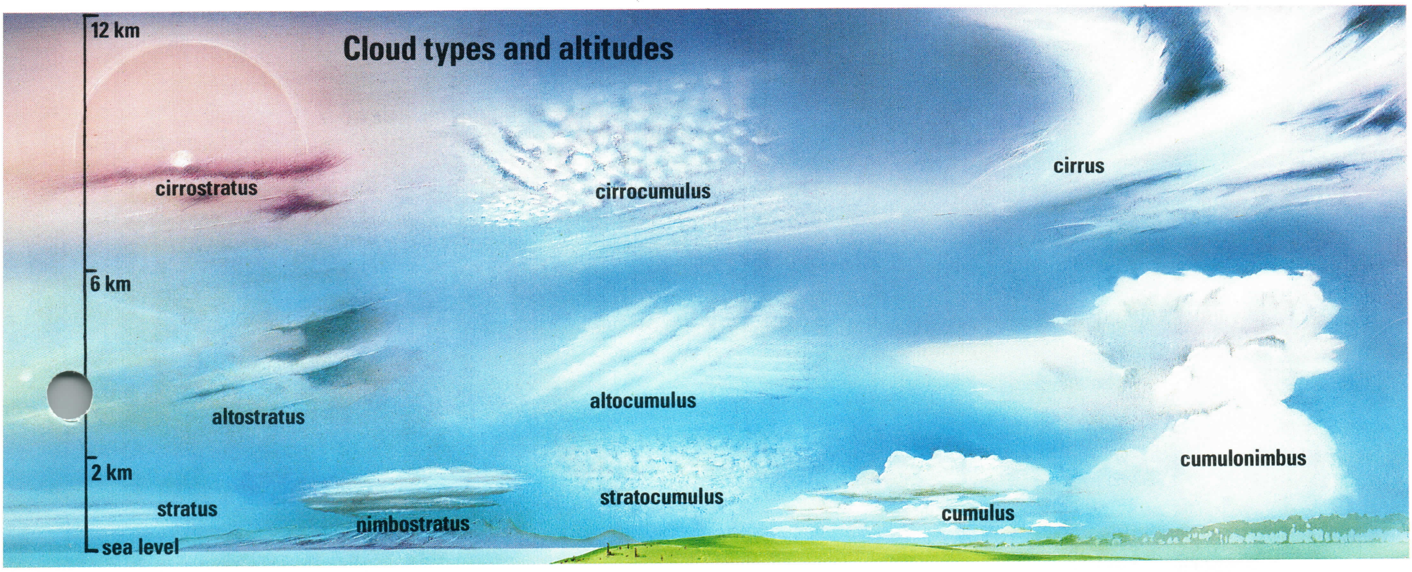
IN ONLY 24 HOURS, A RECORD 1.87 METRES OF RAIN FELL AT CILAOS IN THE INDIAN OCEAN ISLAND OF REUNION. IF IT HADN'T RUN OFF, THE WATER WOULD HAVE DROWNED EVERYONE UNDER 1.9 METRES TALL.


Paul Raymonde



***Tropical regions** have snow on high ground. The warm Earth heats the atmosphere from the bottom, so temperatures are much lower than those at sea level.*

***Cloud names** are based on their height and appearance. The three basic types are cirriform (wispy clouds), cimuliform (heap clouds) and stratiform (layer clouds).*



Norman Myers/Bruce Coleman Limited

On average, about half of the Earth is covered by clouds at any time – and it is not only when fronts mix that they form. Whenever air carrying water vapour cools below a certain temperature, clouds of water droplets or ice crystals form.

Clouds sometimes form when a wind carrying water vapour hits a mountain range. The wind is suddenly forced upwards, so it cools and water vapour condenses out to form clouds. This explains why mountain ranges are often very wet on the windward side and less so on the leeward (sheltered) side.

Another way for clouds to form is when a small bubble of air over a particularly hot piece of land is heated so that it rises through colder surrounding air. Eventually it gets high enough to cool down to the point where water vapour condenses out to form a cloud. A typical example of this type of cloud is the fair-weather cumulus.

Telegraph Colour Library

***Jet streams** are high-speed, high-altitude belts of wind. A subtropical jet stream encircles the Earth and its path becomes visible when clouds form within it. A local jet stream is usually some thousand km long, a few hundred km wide and a few km deep.*

Carol Hughes/Bruce Coleman Limited

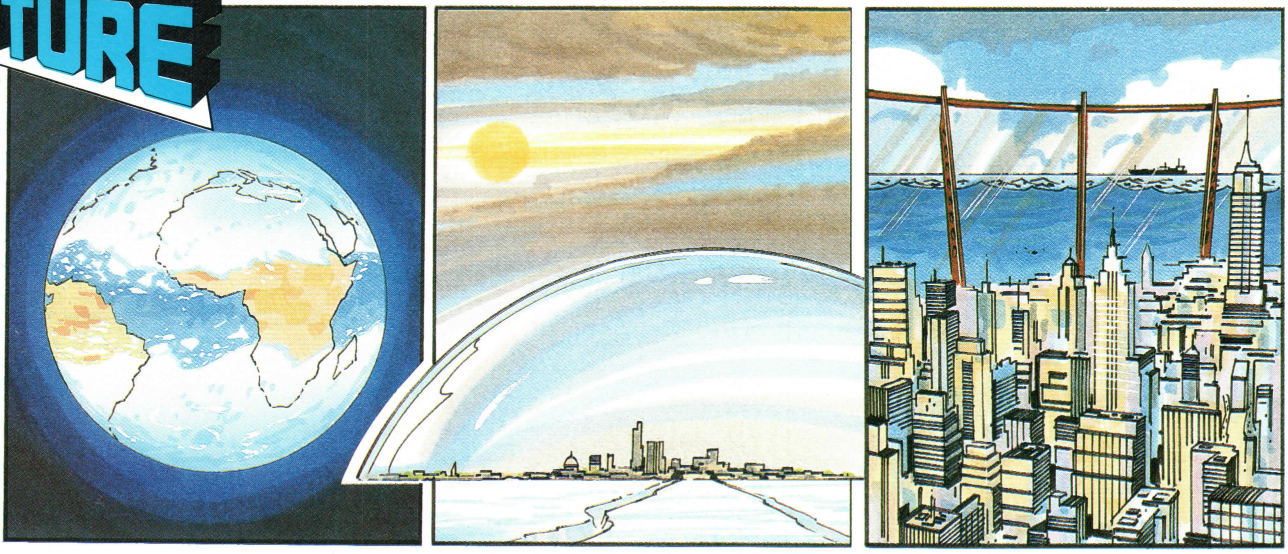
***Fog banks** drift across the sand dunes along the coast of South West Africa. This occurs when moist warm air blows in from the sea in the early morning. The cold land cools the air, causing water vapour in it to condense to form clouds of tiny water droplets.*

## Fog and mist

The sailor's curse and the motorist's nightmare, fog, like cloud, is formed when moist air cools and cannot hold as much water vapour. Typically, sea fog occurs when a warm, moist tropical air mass moves over a cold sea. Close to the water, the air cools and the water vapour that it contains condenses to form tiny droplets. Over land, fog occurs when air cools close to the Earth's surface and, again, water droplets condense. This often produces a morning mist when the land has cooled rapidly overnight under a clear sky.

## INTO THE FUTURE

### COPING WITH DRASTIC WEATHER CHANGES



*▲ Variations in the Earth's orbit cause long-term changes in our weather. For instance, another Ice Age could occur sometime in the future.*

*▲ To combat the cold, cities in what are now temperate regions may have to be covered with plastic or glass in order to trap some of the Sun's heat.*

*▲ But if the Earth became hotter instead, the icecaps would start to melt. Barricades would be built around low-lying countries to prevent flooding.*

Joe Lawrence

TRANSPORTING OIL

DANGEROUS LOADS

IMPROVED DESIGN

# THE CARGO CARRIERS

**A REVOLUTION HAS TAKEN place in the world's merchant shipping in the last 35 years. Huge tonnages of cargo are being moved faster, by a far smaller number of seamen and dock workers, than ever before.**

Much of this cargo is carried by enormous ships that use on-board computers to co-ordinate satellite navigation information and data to plot the fastest, most economical routes across the ocean.

When the Suez canal was closed by war in 1956, Middle Eastern crude oil suddenly had to be transported around Africa to European refineries. This was a powerful stimulus to economize on transport costs by increasing the size of oil tankers.

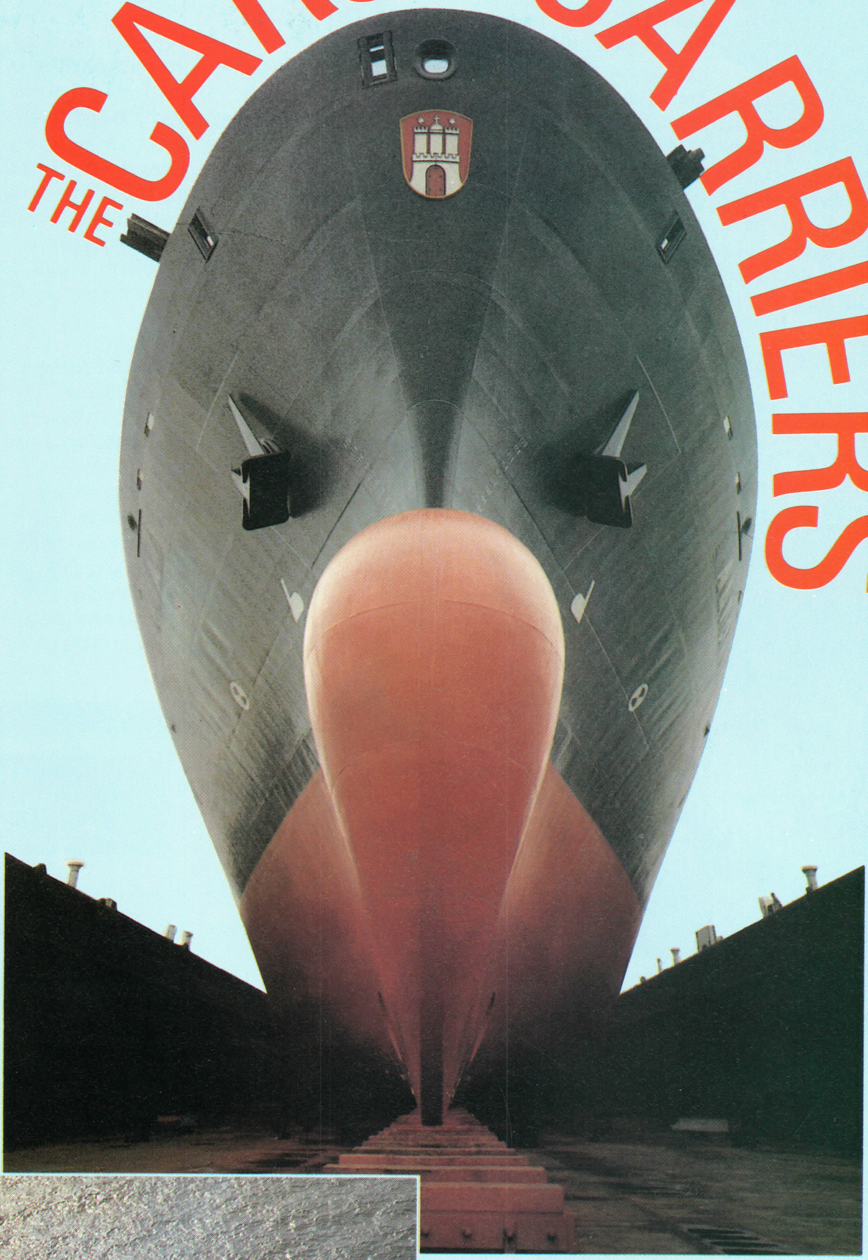
## The supertanker

In 1959 the first tanker capable of carrying 100,000 tonnes of oil was launched. The size grew until ULCCs (Ultra Large Crude Carriers) capable of carrying over half a million tonnes were launched.

One of these monster ships will rarely encounter a port that it can enter. It moors offshore and pumps its cargo into smaller tankers – each of which would itself have counted as a giant 30 years ago. Or it pumps the oil into a pipeline leading from a buoy many kilometres off-shore.

A crew of perhaps 35 people can run one of these monsters. In fact, the ship can sail itself in the open sea, though not when it comes into coastal waters. The levels of oil in all the tanks, the settings of valves, temperatures and such can all be read from instruments on the bridge.

The crew enjoy the highest standards of comfort to compensate for the weeks at sea, with accommodation far superior to that found in old



Flender Werft Aktiengesellschaft

***New generation cargo ships** sport a great bulge in the bow below the water line. This modifies the flow of water at the bow and helps conserve energy.*

A Shell Photograph

***At 310,000 tonnes**, the Japanese-built oil tanker SS Lanistes burns about 160 tonnes of fuel every 24 hours when moving at full speed.*

cargo ships. They even use bicycles to get from one end of the deck to the other – after all, it can be more than 300 metres from bow to stern.

## Ore/oilers

An oil tanker will return empty to the oilfields when it has discharged its load at the refinery, because the tanks cannot be cleaned out completely. In future, ships will be able to carry other sorts of cargo in the tanks on the return journey. Such vessels are called OBOs (oil/bulk/ore), or ore/oilers. Tanks running centrally along the length of the ship can carry either oil or a solid cargo. Other tanks flanking these carry either oil or ballast water.

Nevertheless, some heat eventually gets in, and this is allowed for by letting some of the liquefied gas boil off, at the rate of a fraction of one per cent every day.

## Containers

Equally dramatic developments have taken place in the transportation of goods. Starting around 1960, the developed countries' docks and cargo fleets have been transformed. They have become one huge network to facilitate the flow of cargo in standardized containers. By international convention these are 2.4 metres wide by 2.4 metres high, and multiples of 3 metres long.

Almost any dry cargo whatever can be carried in containers, which are 'stuffed' where the cargoes originate or at special 'groupage' depots. Cargoes take up more space packed this way and each tonne may now occupy five cubic metres – more than twice as much as formerly. Nevertheless, a staggering increase of productivity came with containerization. Cargo handling in docks was speeded up by more than ten times, losses and damage were a tenth of their former values, yet all this could be carried out with only a third of the labour force.

## The ro-ro ship

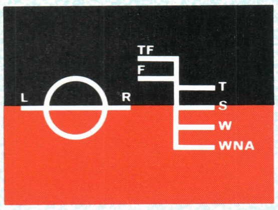
At one time, motor vehicles were loaded on to ships by cranes. During World War II, tank landing ships were developed: tanks could be driven straight on to and off these. After the war, some of these craft became the first ro-ro (roll-on roll-off) car ferries. But it was not until 1957 that the first purpose-built civilian ro-ro ferry was launched.

Short-distance ferries can load and unload through doors at both bow and stern: longer-range ships may be large enough to permit

A Shell Photograph

***Computerization** is the key to low manning levels on these enormous vessels. Modern tankers normally have a crew of between 25 and 35. Smaller vessels with manual equipment need a bigger crew.*

### KEEPING THE SHIP IN LINE




Ships must not be loaded too heavily, or they will be at risk of sinking in heavy seas. The Plimsoll mark shows how deep in the water the ship may safely go. For a given load the ship will float higher the denser the water is. Salt water is denser than fresh, and cold water is denser than warm.

So there are various markings corresponding to different circumstances. The lines on the left marked F and TF represent fresh water and tropical fresh water respectively. The lines on the right all correspond to salt water: the letters stand for tropical, summer, winter, and winter North Atlantic. (The North Atlantic suffers from very heavy seas in winter, and the ship must be less heavily laden then.) LR stands for Lloyd's Register, the organization that makes shipping safety rules. The 'mark' was named after Samuel Plimsoll.

Trevor Vertigan

Natural gas is a valuable product of the oil wells that is now transported by specialized ships called LNG (liquefied natural gas) ships. LPG (liquefied petroleum gas) ships use a combination of high pressure and low temperature to keep their cargo liquid. This processing is carried out at a plant on-shore.

To liquefy the gas, it has to be cooled below – 161°C. The liquid is kept in heavily insulated tanks.

A Shell Photograph

***Heavy insulation** is used on LNG vessels to protect the liquefied natural gas from the relative warmth of the sea. The small amount of gas that does 'boil off' during loading is used to fuel the main boilers.*


***Container ships** carry cargo in their hull and also on deck. Any deck cargo must be properly secured, not only to prevent loss at sea but also to ensure the ship remains stable in heavy seas.*

Fotoflite


***Cargo is loaded** on to lorries directly from the ship, which considerably reduces the length of time a container ship has to remain in port. This method of transportation also reduces cargo damage.*

P & O Containers Ltd

vehicles to manoeuvre, so there are doors at the stern alone. An adjustable ramp is required at the dock to form a bridge to the vehicle deck no matter how high or low the tide is.

Some ro-ro ships are loaded with trailers that are brought on by trucks that then drive off again. They are unloaded by other trucks at their destination.

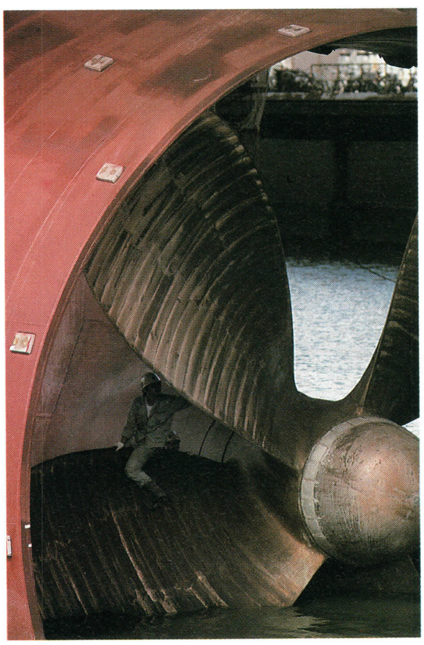
Even in the jet age, ships are being constantly transformed by dramatic technological innovations. One design that is attracting excited attention at the moment is the SWATH (small waterline-area twin-hull) ship. In this the load-carrying structure is carried above water level by twin hulls, catamaran-style. The minimal 'wetted' area in the water minimizes drag.

The big cargo ships of today need a great deal of power to push them through the water. A typical container ship may have two engines of 25,000 horsepower each. A marine diesel engine can weigh 1,600 tonnes and be four storeys high.

Nevertheless, the ships use much less power in proportion to their weight than the ships of yesteryear. Each horsepower of an ultra large crude carrier's engines propels about 13 tonnes of ship through the water – more than four times as much as for a typical tanker of the 1950s.

This improvement is due to a number of factors:

- Controllable pitch propellers, in which the angle of the blades is changed according to the ship's speed.
- Improved hull design. For example, a great deal of the energy used by a ship goes into making waves. Now all large modern ships have a



***The ducted propeller**, which has a ring around the blades, is used in preference to the open propeller. Being more efficient, it uses less fuel and, therefore, reduces operating costs.*

Martin Rogers/Colorific!


***Roll-on roll-off** car ferries opened up the rest of Europe for water-bound Britons. Doors at both bow and stern allow drivers to literally 'drive through' the vessel. Long range ferries often have only one opening, but are large enough to allow drivers to turn their vehicles around.*

Sealink British Ferries Ltd


Daudier/Jerrican

bulge at the bow beneath the waterline. This reduces the size of the bow wave, and hence reduces the energy wasted.

- Ducted propellers. These incorporate a ring around the propeller and are more efficient than open propellers.

## Building methods

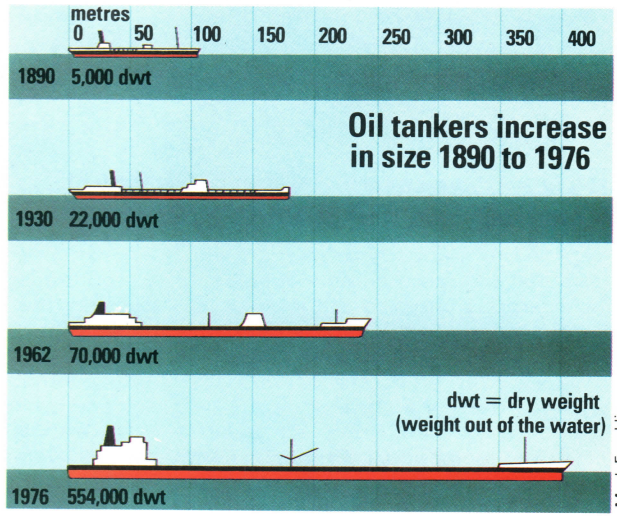
Along with the revolutions in the design of ships and in the work they do, there has been a revolution in the method of building them. Formerly workmen jostled in the confined space of the ship's hull, at the mercy of the weather, as it was built on the slipway from which it would be launched. Now prefabricated sections are built in covered lofts, and transported to the building dock, where they are assembled. Construction is simplified by designing ships with as many flat plates (panels) as possible.

In an age that is conscious of the price of oil, everything that might save fuel is eagerly seized on. So, although we shall not see the return of the sailing ship, there might be an important place for the sail-assisted motor vessel in the future.

The French-built *Wind Star* is a four-masted cruise yacht. Her sails are largely intended as a tourist attraction, but they will also provide a fuel saving. A computer controls the sails and the diesel engine jointly. Passengers are allowed to have a go at steering the boat and watching the sails being automatically reset as they turn the wheel.

Sails are not the only way of getting help from the wind. Vessels can be towed by kites. Rotating vertical cylinders – in the air, the water, or both – can also generate forces that can be used to help a boat along, or to steer it, with less energy loss than an ordinary rudder.

***The first fully** automated sail-assisted ships –* Usuki Pioneer *shown – had two rigid masts. The sails are controlled by a computer and can be folded when wind conditions are not favourable.*




Mark Franklin

***Ultra large crude** carriers, weighing over 500,000 tonnes, were built in the mid-70s; a change in the oil market since then has meant tankers are unlikely to be larger.*

## THE SEMISUBMERSIBLE SHIP

An important modern type of ship is designed to be sunk – or half-sunk, at any rate. Called the semisubmersible ship, it solves the problem of getting heavy loads on board. Tanks on the ship are flooded and it sinks until just its bow and stern superstructures are above the water. The load is then floated over the centre section and the tanks are pumped empty; the ship rises again, lifting its new cargo.

In the LASH (lighter aboard ship) system, barges (called lighters) are floated on to a semisubmersible mother ship. They can then be carried across oceans and floated off to continue their journey on inland waters. Cargoes are carried between the Mississippi and the Rhine in this way.

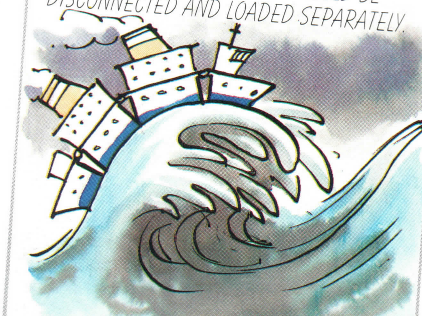
Semisubmersible ships can be used to pick up damaged ships for transport back to a ship repair yard.


Fotoflite

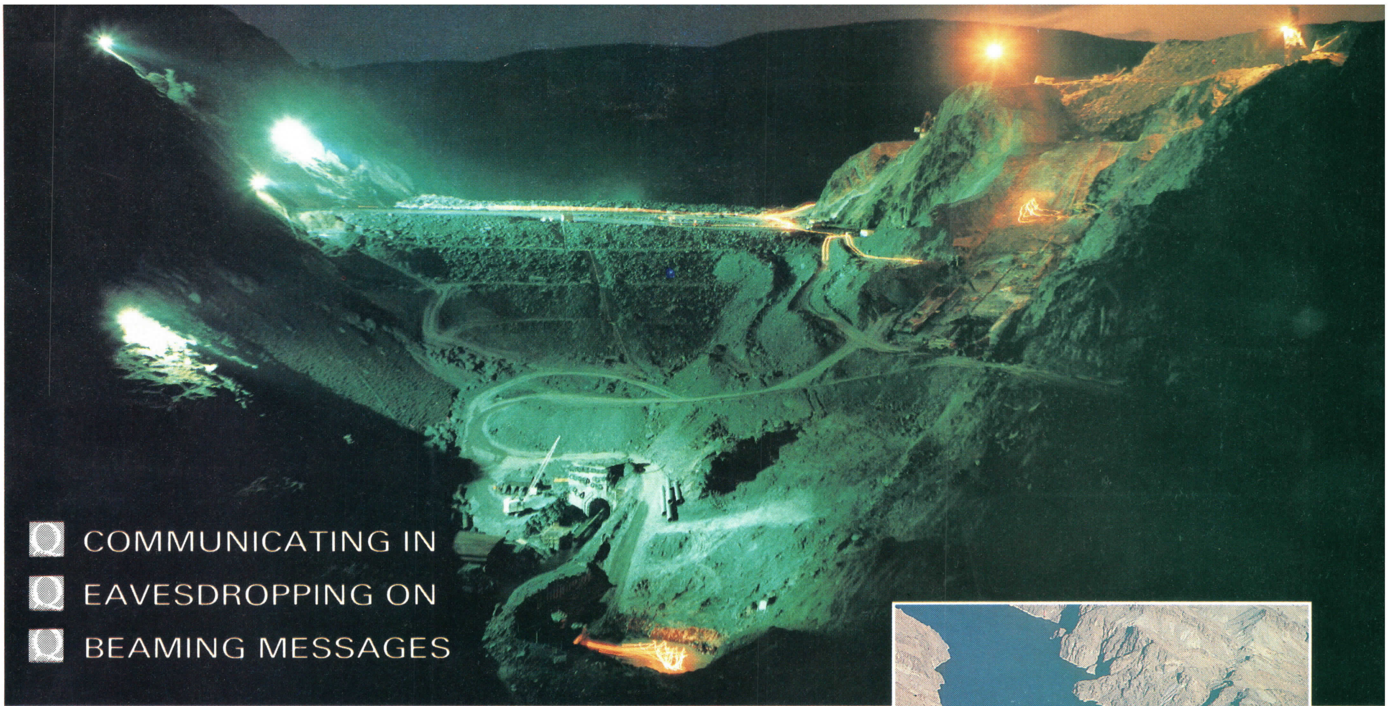
### Just amazing!

**JET AGE SHIPS**

ONE OF THE FIRST LARGE CARGO SHIPS, A 19TH CENTURY SHIP CALLED THE CONNECTOR, HAD THREE OR FOUR HINGED SECTIONS TO LET HER RIDE THE WAVES MORE EASILY. EACH SECTION COULD BE DISCONNECTED AND LOADED SEPARATELY.



Paul Raymonde

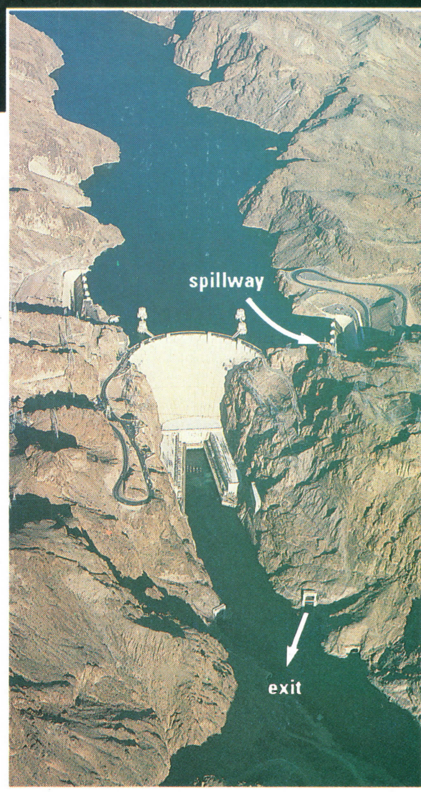



George Wimpey PLC

*Earth dams are built using a network of temporary roads for the tipper trucks and bulldozers to move around on.*

# WATER BARRIERS

*Spillways on the Hoover dam in the USA lead surplus water off into side valleys, then away through tunnels cut in the rock.*




Spectrum Colour Library

**THE POWER TO TAME RIVERS, control torrents and drive back the sea is given to comic book superheroes at the time of their birth. The rest of us need dams, locks and sea walls to accomplish the same feats. Dams are the commonest man-made water barriers.**

Dams are built across rivers for one or all the following reasons:

- To create reservoirs
- To generate electricity
- To feed irrigation systems
- To control floods.

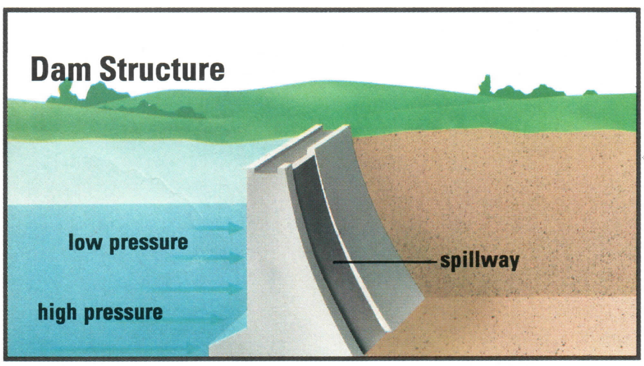
The colossal Nurek Dam on the Vakhsh River in Tadjikistan in the Soviet Union stands 317 metres high and is 730 metres long. It provides hydro-electric power for the local people, plus irrigation and drinking water for an area of more than 10,000 sq km.

Dams are built in one of two ways. They are either made of rock and earth fill or of concrete. Rock-and-earth fill dams have to be much thicker than concrete structures because they depend on sheer weight for their strength, rather than the structural properties of reinforced concrete. They are mainly used to create irrigation reservoirs in relatively flat and wide river valleys.

Earth dams can also be far bigger than concrete ones. The largest one in the world is the Pati dam on the Pavana River in Argentina, which is 174.9 km long, 36 metres high and is made of 238 million cubic metres of compacted earth-and-rockfill.

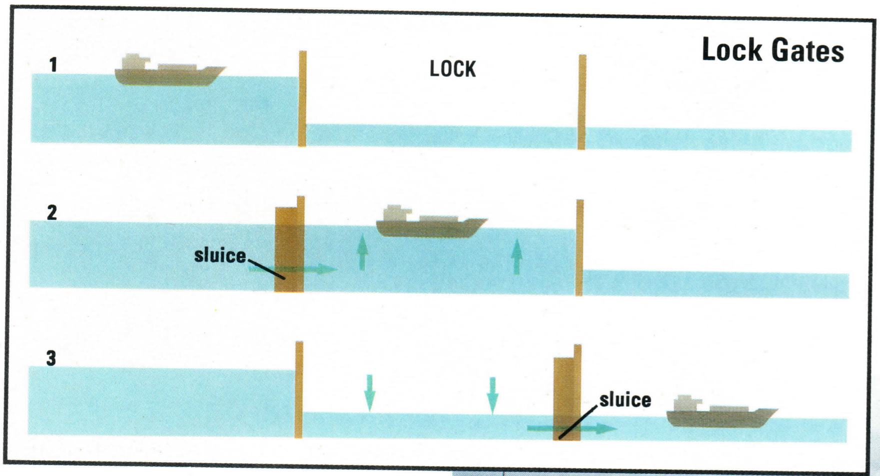
For comparison, the largest concrete dam in the world is the Grand Coulee Dam on the Columbia River in Washington State, USA. This is 1,272 metres long, 167 metres high and 8 million cubic metres of concrete were poured into the structure during construction. Typically, concrete dams are built across narrow valleys, where the ends of the dam can be securely anchored on the rocky sides of the valley.

Whatever the design of a dam, it must be broader at its base than at its top. This is because the pressure of water against the face of the dam increases with depth. A sluice or spillway is always built into the design so that, when the water level is close to the top of the dam, water can be let out of the reservoir. If the water was allowed to simply overflow, it might easily undermine the dam and cause it to collapse.




Janos Marffy

*Dams are always built with a broad base to withstand the higher pressure of deeper water. Spillways, normally built into the sides of the dam, allow surplus water to be drawn off by the dam engineers. The overflow is controlled by electric sluices.*




Janos Marffy

***1 A lock** is sealed at either end with pivoting gates. **2** Before a vessel can enter, the water level in the lock is equalized with the level outside; this is done by opening the sluices in the base of the gates. **3** The process is repeated at the other end of the lock, so the vessel can sail on. Lock gates always open towards the deeper water – the water pressure forces them together, improving the seal.*

Steve Kaufman/Bruce Coleman Limited

***Twin locks** on the Panama Canal allow ships going in opposite directions to bypass the water barriers without delay. Locomotives haul the ships through the lock.*

Netherlands Board of Tourism

***The Delta Works** in Holland are 30 km long and control the rivers Scheldt, Rhine and Maas. They also generate electricity and keep the sea out during storms.*

The designers and builders of large dams carry a heavy responsibility: if a big dam breaks, thousands of people and animals could be drowned and the devastation to communities could equal that of a natural disaster.

The sea is the other great mass of water that man sets out to control. Natural areas of sheltered water, where ships can seek refuge from storms and unload their cargo, are usually extended and improved with harbour walls. Where possible, harbour walls are built out into the sea from opposite sides of the harbour, leaving only a narrow entrance giving access to the open sea.

## Soft shorelines

Where the shoreline is made of soft rocks such as chalk or clay, the sea will erode it by up to 10 metres a year. If a soft cliff is reinforced at the base with a concrete sea wall, the erosion can be halted. Where the shoreline is made of pebbles or sand, sea walls often have to be replaced every 30–50 years as the loose material they are built on shifts around, leaving the sea wall too weak to resist winter storms.

Another form of barrier against the sea, used to protect low-lying land, is a dyke. Where areas of standing water are enclosed by dykes, the water is pumped out to form a 'polder' – an area of reclaimed land.

The most spectacular inland water barriers are rapids and waterfalls. Locks allow cargo ships and boats to bypass such barriers. They permit ships to transfer easily from one water level to another. Flights of locks – where one lock leads straight into another – allow ships to get over some quite high mountain ranges.

### DAM DISASTERS

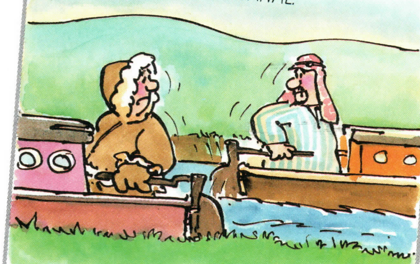
Popperfoto

Dams in earthquake zones are a potential danger to people downstream but disasters can also be man-made. The big dam at Fréjus in the south of France collapsed in 1959 sweeping away part of the town and killing over 300 people. The dam took eight years to build and cost £580,000; it was the thinnest structure of its kind. Damage was estimated at over £1,500,000. A geological fault had weakened the rock structure.

### Just amazing!

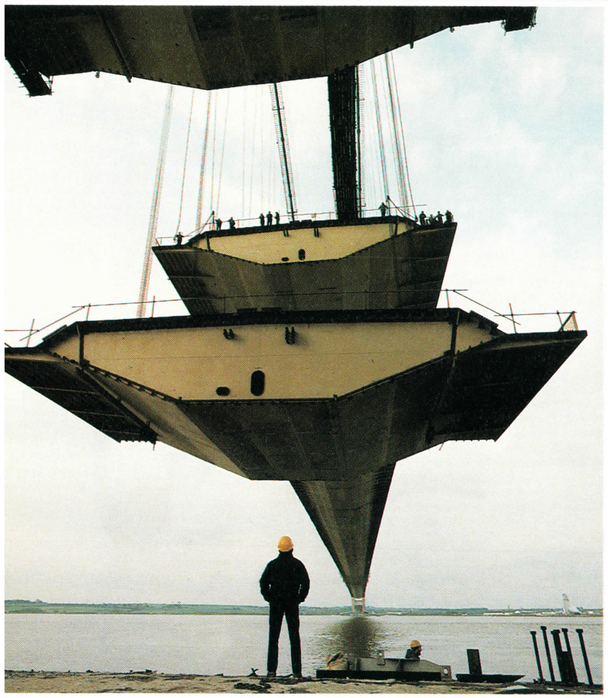
**GIANT WATER WAY**

THE LONGEST CANAL SYSTEM IN THE WORLD RUNS FROM NEAR-DESERT AT ASTRAKHAN ON THE CASPIAN SEA UP TO LENINGRAD ON THE FROZEN BALTIC. THIS IS 2,300 KM – FIFTEEN TIMES THE LENGTH OF THE SUEZ CANAL.



Paul Raymonde

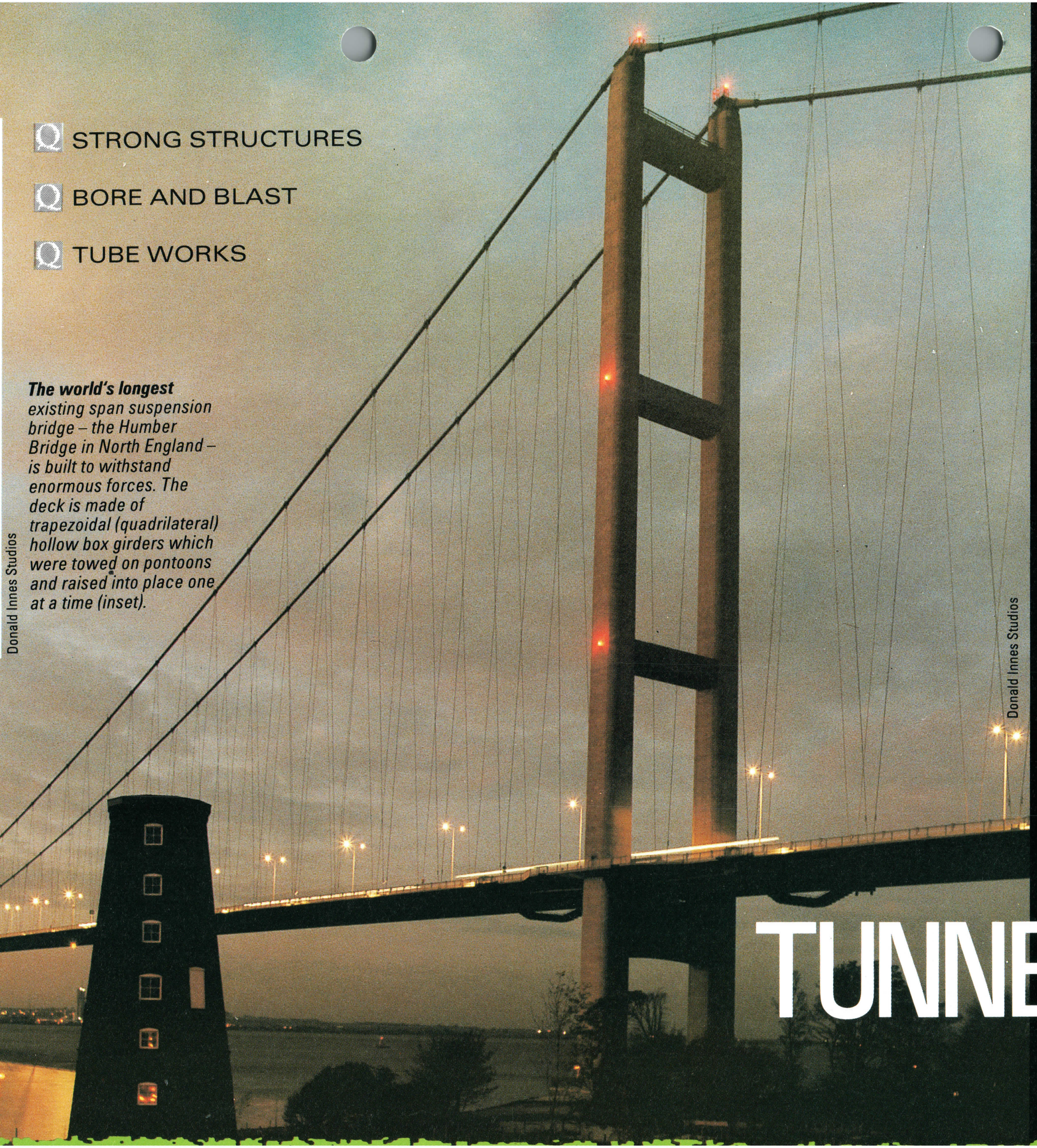
# BRIDGES AND TUNNELS



Donald Innes Studios

- STRONG STRUCTURES
- BORE AND BLAST
- TUBE WORKS

***The world's longest*** *existing span suspension bridge – the Humber Bridge in North England – is built to withstand enormous forces. The deck is made of trapezoidal (quadrilateral) hollow box girders which were towed on pontoons and raised into place one at a time (inset).*



Donald Innes Studios

**SPANNING OBSTACLES OVER and underground, modern bridges and tunnels are some of the most daring and beautiful structures ever devised by engineers.**

There are several different designs of bridge, but they all share certain common problems. A bridge should be strong enough to support itself and the traffic that crosses it in any weather conditions.

The simplest kind of bridge to build is one that can cross the obstacles in one span. However, such bank-to-bank bridges can only link short distances, as they are limited by the length of the largest available steel and concrete girders. Most bridges, therefore, need supporting pillars built at some point along their length.

## Suspension bridges

The longest bridges in the world are suspension bridges. In this design, the bridge deck hangs from thick steel cables which stretch from one bank to another, up over huge supports. The deck is attached to the cables by steel wires under high tension.

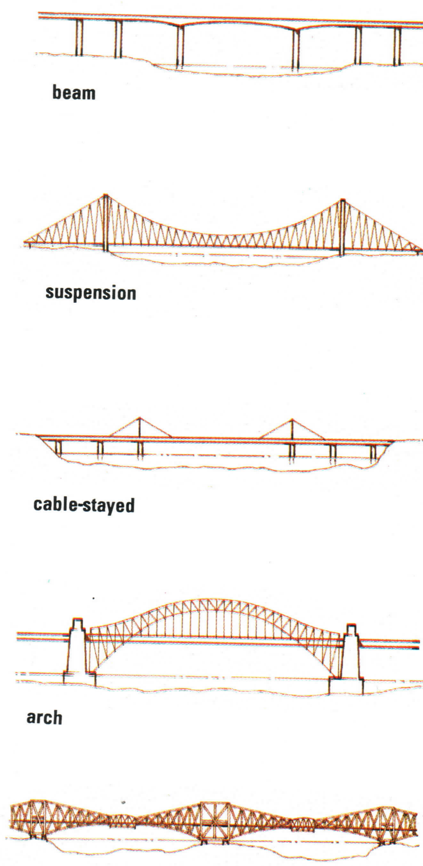
Where a bridge crosses a river or a stretch of water, there is the immediate problem of building a support underwater. This is solved by using a cofferdam, a watertight enclosure that is towed out to the point where the support is to be built, sunk and then pumped clear of water. The river bed must then be excavated down to bedrock or other strata strong enough to support the load-bearing pillars.

The 'cantilever' principle, whereby props from the main supports hold up the deck, can extend the single-span considerably. However, while a cantilever bridge does not strictly need supporting columns along its length, it does usually require intermittent 'props'.

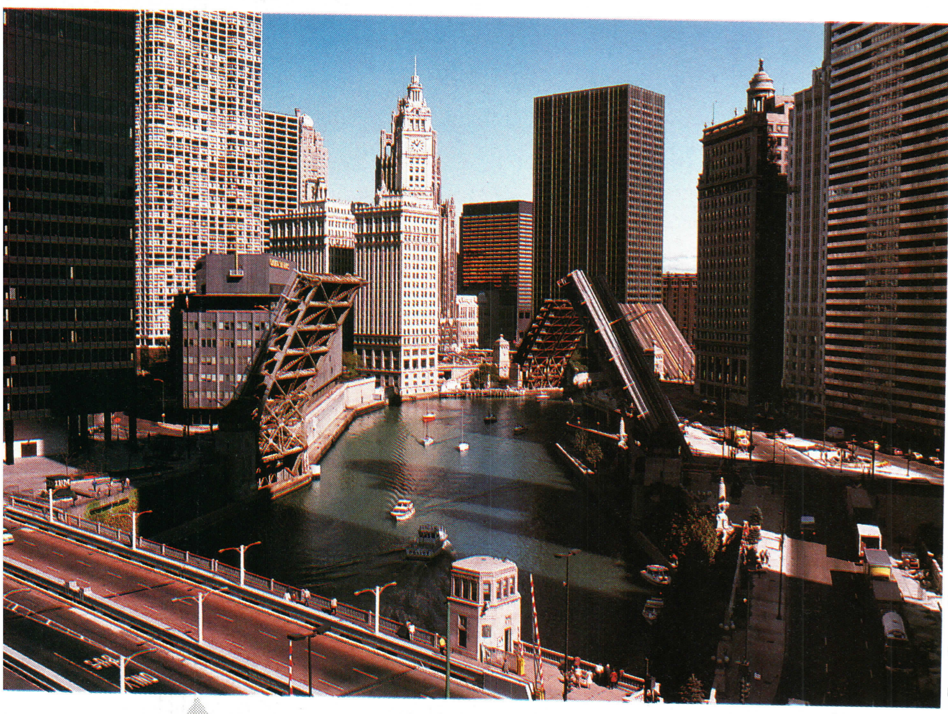
Sometimes bridges need to be built where they would interfere with the passage of ships up and down a waterway. An alternative to tunnelling under the water is to build a moving bridge, all or part of which can be moved to allow ships through. Swing bridges, for example, have movable sections that swing aside horizontally to let ships pass through.

Cable-stay, steel truss, girder and beam bridges have different means of support, but in most cases, the weight is carried ultimately by the supporting columns. The fewer the columns, the greater the load they have to bear; on any bridge, about 90 per cent of the total weight it has

## Basic Bridges




Chris Lyon



Tony Stone Photo Library, London

*Downtown Chicago must use all possible routes for traffic, including the river. Bascule bridges – like London's famous Tower Bridge – raise their decks on pivots that glide on rails, thus making the river navigable inland.*

Spectrum Colour Library

***The steel arch** bridge over Sydney harbour, Australia carries both road and rail traffic. Capable of taking very heavy loads, it was tested with the weight of 72 locomotives – a total of over 77 tonnes.*

**PROFILE** BRIDGES

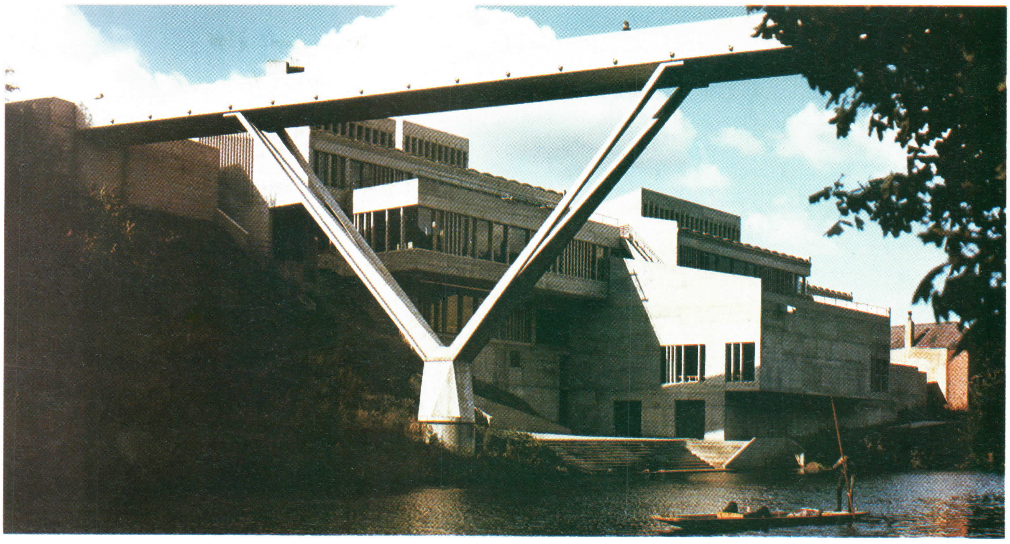
New building techniques and materials mean that bridges can now be made even longer, wider and higher than before.

**Longest span**
Humber Estuary Bridge, England, UK
1,410 metres
Akashi-Kaikyo Bridge, Japan, (to be completed 1998)
1,980 metres

**Widest**
Sydney Harbour Bridge, Australia
48.8 metres

**Highest**
Royal George Bridge, Arkansas River, USA
321 metres above water level

***The slim-line*** *Kingsgate footbridge in Durham, England, designed by Ove Arup, is a fine example of the use of concrete. Two braced V piers support a continuous U-shaped girder, using an absolute minimum of materials.*



George Wimpey PLC

***Two arms*** *reach out to meet each other and complete a box girder bridge. The box girder principle, so popular today, is used in both steel and concrete bridges. Box girders can come in a variety of cross-sections.*

Spectrum Colour Library

***In drive-through*** *tunnels, lighting is bright at the openings, so that drivers are not blinded on entering the tunnel nor dazzled on leaving it. Inside, the lighting is dimmed, as cars keep their lights on in tunnels.*


Spectrum Colour Library

to carry will be contained in its own structure.

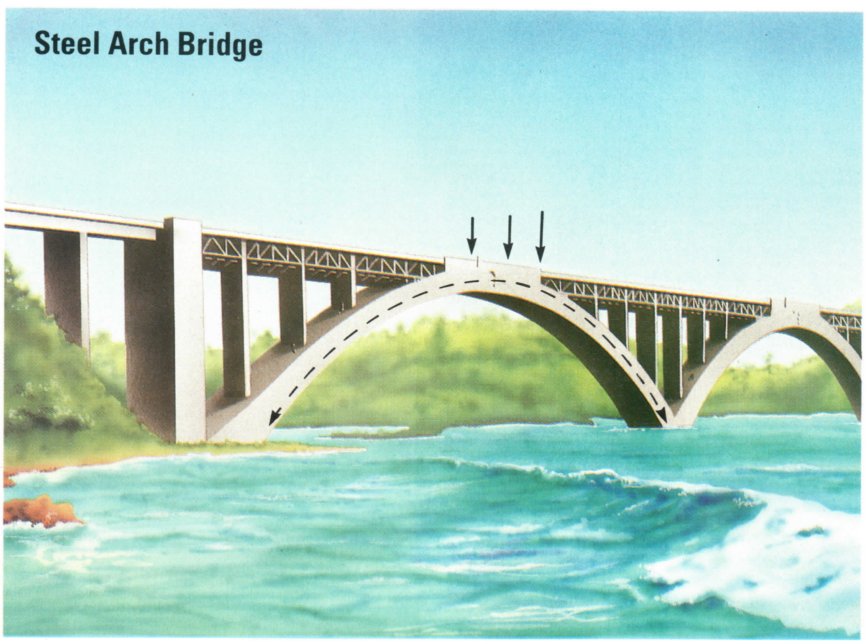
Apart from ensuring that a bridge has sufficiently secure foundations and structural components to carry its own weight, engineers also have to consider the impact of winds blowing into the bridge sideways. They do this by testing models in wind tunnels to assess the necessary lateral stability. Many of these tests can also be simulated on computers.

Wind shields can also be built on the sides of bridges which have to endure violent gales. These plates both protect people and traffic crossing the bridge and deflect the force of the blast as it strikes the bridge.

From time to time, bridges collapse. Perhaps the most famous failure was that of the Tacoma Narrows suspension bridge built across the Puget Sound in Washington State, USA, in 1940. Just six months after completion, the deck began undulating ever more severely in a light gale and

***Four tunnels*** *under construction for the New York subway. Underground rail tunnels are usually made by the 'cut and cover' method.*

New York City Tourist Authority




Chris Lyon

***Arches are strong structures*** *because the weight at the top is deflected down the sides. This compresses the materials in the sides, making them stronger.*

crashed into the water in one hour.

Most bridge accidents happen during construction, however, such as the collapse in August 1988 of a concrete beam bridge in Aschaffenburg, West Germany. Seven people were injured; one was killed.

## Cutting tunnels

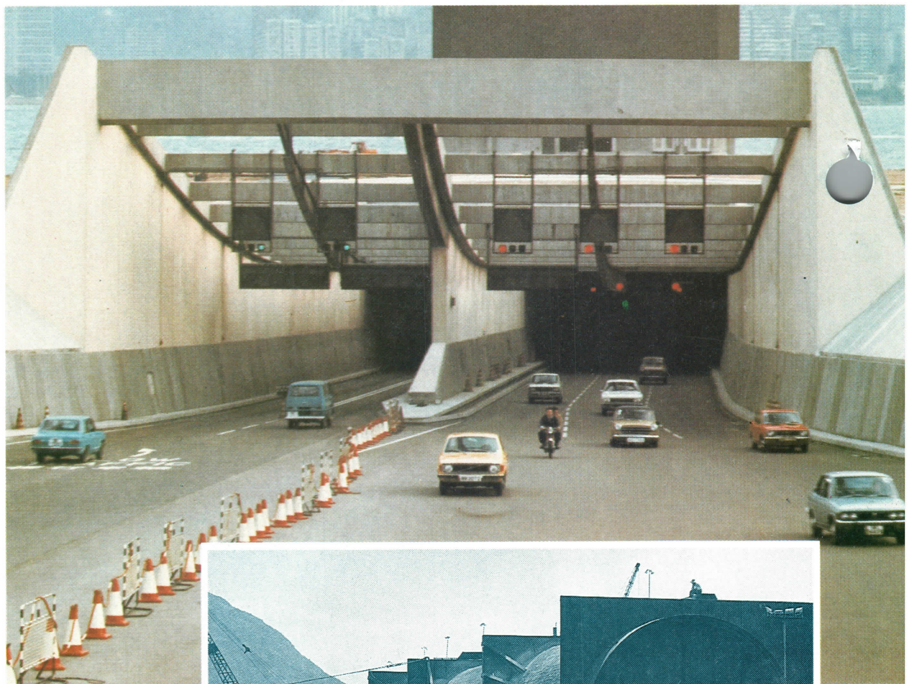
If bridges are the way to cross over natural or man-made obstructions, tunnels are the way to go underneath. The traditional method of making a tunnel is to bore one.

In soft ground, such as the chalk through which the Channel Tunnel was bored, a giant tunnel boring machine can be used. This resembles an enormous drill, which can be as long as 190 metres. The cutting head at the front is of the same diameter as the tunnel, and it is forced along the tunnel by hydraulic power. Behind the rotating cutting head is a series of conveyor belts. These take away the spoil to rail mounted wagons behind the machine that takes the waste above ground.

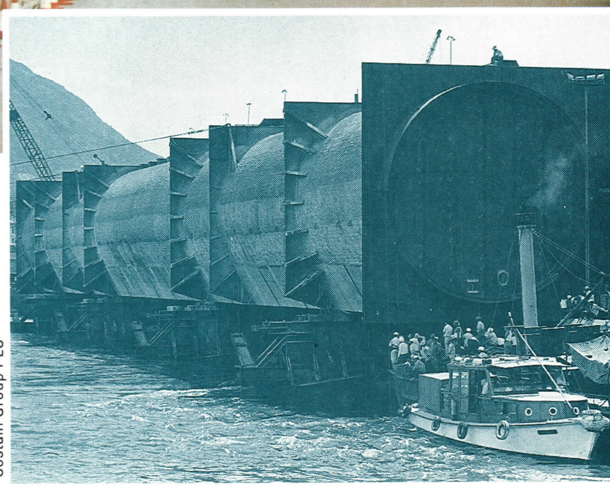
Behind the cutting head, the excavated tunnel is lined with segments of reinforced concrete or cast iron. The segments form a circle around the inside of the tunnel and, because the pressure bearing in on a circle is roughly equal from all sides, the lining prevents the walls or the ceiling from collapsing.

In hard ground, such as rock, tunnels are drilled and blasted through. Small holes are drilled at a short distance into the tunnel face and packed with explosive. When charges are fired, the drilled section crumbles and is cleared away. Then the process is repeated.

Tunnels through rock do not usually need linings – the rock forms its own load-bearing arch. However, if the rock contains many faults, it may need lining.



George Wimpey PLC



Costain Group PLC

***Tunnels join** Hong Kong to the Chinese mainland. The new Hong Kong-Kowloon tunnel will probably be the biggest in the world. Gigantic precast tunnel units (right) are lowered gently beneath steel pontoons anchored to the sea bed.*

***Building the 'Chunnel'**. Steel sheets are driven into the sea bed from jack-up barges to form a lagoon which will be filled up with tunnel spoil.*

Costain Group PLC

## Unstable rock

Sometimes rock conditions are so bad that the rock ahead has to be stabilized before it can be blasted. The Japanese had to do this on the Seikan Tunnel. To make the rock secure enough to drill and blast – without causing uncontrolled collapses – the tunnellers had to drill holes in a fan shape outwards about 100 metres in front of them, then inject a cement grout into them. When the grout hardened, it made the rock tough and stable enough to tunnel through.

For tunnels under water, submersed tubes can be an alternative to a bored or blasted tunnel. This type of tunnel is made up of giant prefabricated sections, which are floated into position and sunk to the sea bed. They are then joined together and the joints are sealed.

The tunnel sections are usually lowered into a previously excavated trench on the bottom, which gives the completed tunnel a degree of extra protection. However, as in the case of the Hong Kong–Kowloon tunnel, the trench bottom is not even enough to lay the sections on, so an even bed of sand must first be laid down. Once the tube is laid in the trench, it is usually covered over.

There is also an option for shallow land tunnels: the 'cut and cover' tunnel. Provided there is not too much rock or other strata on top, it can be more economical to make an open cut through the obstacle, then cover it with steel or concrete beams.

### Just amazing!

**FISHERS OF MEN**

SUICIDES WHO JUMPED OFF CLIFTON BRIDGE, ENGLAND, PROVIDED BOATMEN WITH AN INCOME: THE LOCAL COUNCIL PAID FOR EACH CORPSE RETRIEVED.

Paul Raymonde

# SEA STRUCTURES


***The Claymore platform** in the North Sea is a massive steel structure standing in 110 metres of water. This huge oil production platform is anchored in position to the sea bed by steel piles, driven 46 metres into the sea bed.*

## CONSTRUCTING RIGS

## SUPER CRANES

## ARTIFICIAL ISLANDS

**BUILDING HUGE STRUCTURES on water developed through the need to extract oil and gas from fields that lie under the ocean.**

Altogether there are now more than 1,500 oil platforms stationed in the oceans of the world. The North Sea and the Gulf of Mexico are the two offshore areas that have seen the most development.

There are two main types of permanent offshore platform. In most cases, the oil men live and work on a steel structure that contains the drilling rigs and processing equipment as well as sleeping quarters, cinemas and restaurants. It is the supporting structures that vary. One type consists of lattice steel supports, which stand on the sea bed on four or more legs. Other rigs have concrete bases, which are floated into position and then sunk.

### Floating structures

As well as these platforms, which are all fixed to the sea bed, the offshore oil and gas industry has spawned various floating structures. The most impressive of these are crane barges, which can lift up to 14,000 tonnes.

Steel supporting structures, called jackets, once had to be floated out to sea on barges and up-ended when they reached their destination. However, the huge cranes now available can lift most jackets into place from the deck of the barge. Steel piles – giant pipes – are then driven through the base of the jackets deep into the sea bed to anchor them in place.

The discovery of oil and gas in the North Sea led to existing technology being taken to undreamed-of dimensions. For instance, the cylindrical steel piles used to nail the four steel platforms in the Forties oil field (in the North Sea) to the sea bed were 1.37 metres in diameter and 270 metres long – nearly twice the height of the British Telecom Tower in London. Each platform needed 36 of them. Once the jacket has been fixed in position, the decks are placed on top, either in one piece or in separate modules.

### Concrete towers

The concrete structures used to support some oil platforms are the heaviest floating structures man has ever devised. One now being built in Norway will weigh more than one million tonnes. How do such immensely heavy objects float?

The answer is that they have giant buoyancy tanks built into them. These hold enough air to make the structure float and, by emptying and refilling the tanks, the jacket can be made to rise and fall in the water.

The deck is floated out on a barge to a point in deep water to be mated with the jacket. The jacket is lowered in the water so that the barge can float over it. Then the jacket is raised to lift the deck off the barge.

Once a survey and test drilling have shown that it should be economic to build a permanent rig on a

***The steel jacket** of an oil platform, ready to be eased on to a barge for towing out to its destination in the North Sea.*


Occidental Oil

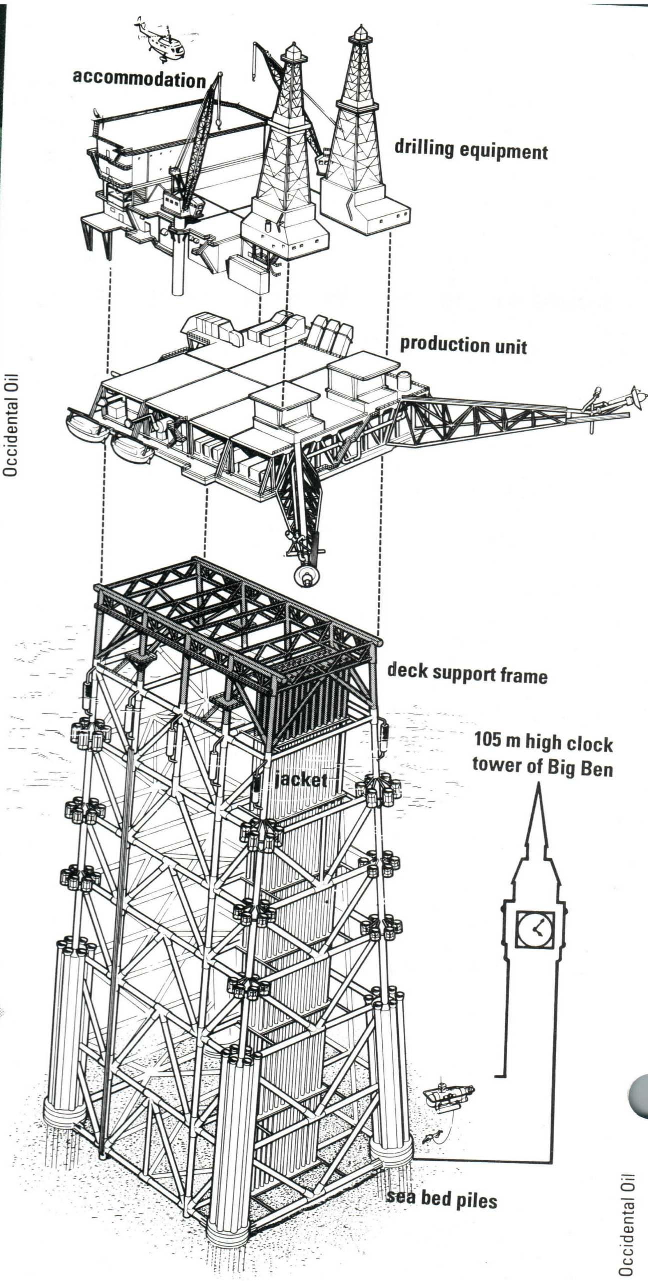
site, planning and construction can begin. A typical modern rig takes at least two years to build. The development of all this technology has encouraged people to look at building other massive structures on water.

## Power station

Italian engineers are working on plans to build a floating power station off their western coast. A similar scheme (with a difference) is being proposed in the Philippines – a small floating power station that would be able to sail around the islands and plug into areas that were facing temporary shortages of electricity.

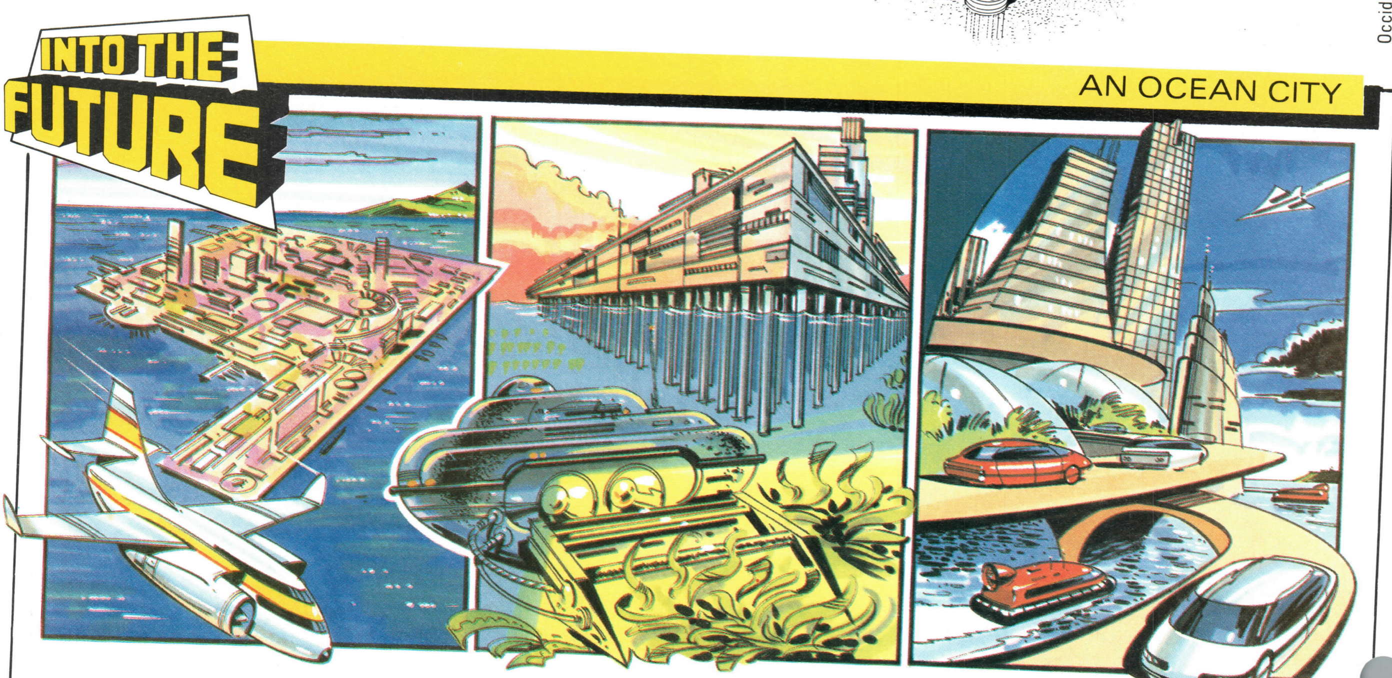
Of course the cost of building on water will always be higher than that of building on land, so offshore construction is likely to happen only where there are pressing environmental reasons for remote locations, as in the case where overcrowding on land forces man to build new cities on artificial islands in the sea.

***High-quality food*** *is prepared in a well-equipped kitchen on the rig. Each week, the rig workers consume about 70 kg butter, 320 kg flour, 450 kg fruit, 2,540 litres milk, 900 kg meat and 450 kg vegetables.*




***The structure*** *of the Claymore oil production platform, clearly revealed. The steel jacket, rising 152 metres from the sea bed would dwarf the 105 metre Big Ben clock tower (in London). The deck support frame evenly distributes the weight of the upper modules to the jacket and the sea bed.*

Occidental Oil



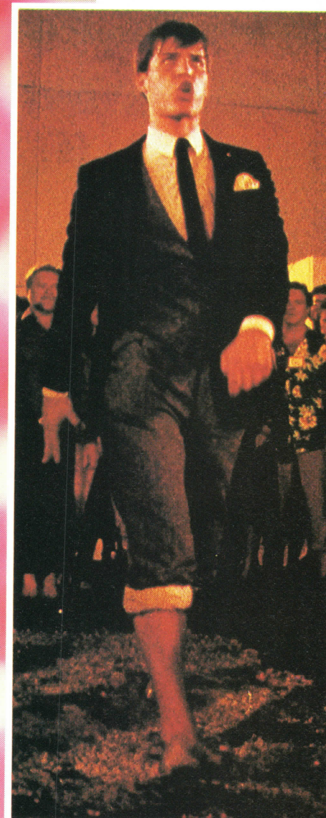

▲ *The Ocean Communications City, an artificial island in the Pacific 120 km from Tokyo, will be home and workplace for up to one million Japanese.*

▲ *Ten thousand shock-absorbing columns will support the 23 km² structure. Underwater farms may provide the inhabitants with fruit and vegetables.*

▲ *Access to this $200 billion sea city will be by plane and hovercraft. Electric cars will provide transport around the island on perfectly smooth roads.*

Joe Lawrence

# MIND OVER MATTER



Scot Sothern/Black Star/Colorific!

Tony Stone Photolibrary London

***The power of the mind** to withstand pain is amazing. A Hindu mystic can turn into a human pin cushion without bleeding because he has learnt to control parts of his mind through special training. Similarly, a man trained to walk barefoot over burning coals (inset above) incurs no injury to his feet.*

***Faith can heal** – but it is not known how. Sick and disabled pilgrims visit Lourdes in France, the site of a miracle, hoping to be cured.*

Terence Spencer/Colorific!

ESP

BEING THERE

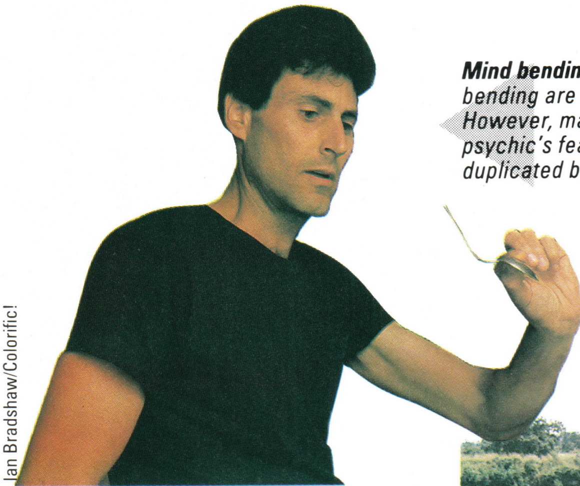
ALTERED STATES

**SPOON BENDING, READING minds, communicating with the dead – these are some of the instances of the paranormal.**

While neurology can explain much that occurs in the brain and the mind, there are many events that cannot be explained using current knowledge. Such events are usually classified as paranormal or extra-sensory perception – ESP.

Among the many instances of the paranormal are:

- telepathy, which is defined as the transmission of information from one mind to another without using any of the normal methods available to human beings, such as language, movement or signs
- clairvoyance, which involves acquiring information that is not known to any other mind – its practitioners argue that the information they receive comes from the spiritual world
- precognition: acquiring information about an event before it takes place, which invariably takes the form of a dream about, say, a disaster occurring
- psycho-kinesis, the ability to manipulate matter or to move



Ian Bradshaw/Colorific!

***Mind bending feats** such as spoon bending are Uri Geller's speciality. However, many of this famous psychic's feats have been duplicated by conjurors.*

***A dowser or diviner** can find water or mineral with (or without) the help of special rods. This particular talent may have something to do with radiation.*

John D. Drysdale/Colorific!

objects from a distance without employing known physical means.

Although paranormal events are widely reported – and there is a great deal of anecdotal evidence, to date – not one repeatable paranormal effect has been discovered or been demonstrated in a controlled, scientific setting.

In controlled studies, persons with reported psychic powers have been unable to harness them in the laboratory. There is also rather damning evidence that shows some laboratory experiments, which apparently proved an individual's psychic powers, were actually fixed or manipulated.

## Hidden powers

However, paranormal events that have been observed often cannot be explained. Some scientists believe that we may be in possession of certain powers that we are not conscious of. Or that we may even have a communication system that works in the manner of radio waves, which we do not know about, or are largely unable to harness. Until research shows otherwise, however, the existence of the paranormal is doubted by most scientists.

An event that nearly everyone is familiar with is that of having already been in a situation, or of having seen something before in another time. Those of certain religious or spiritual persuasions argue that this situation, known as *dejà vu* (French for 'already seen'), is proof of humans living previous lives in other bodies or forms.

More plausible explanations do exist, however. Some would argue that we may have dreamed of the event or situation so vividly that when we find ourselves in that situation it seems all too familiar, since we have 'been there' in our dreams.

Then again, a situation may contain many events and surroundings that we have seen or experienced before, so that we may feel we have been in the situation previously.

One theory of *dejà vu* involves memory. Some argue that a memory of what we choose to store is laid down in the mind, rather than what actually happened. So, although we may have been somewhere that was vaguely similar, the memory of that place has been modified till it is now identical to the situation we are experiencing.

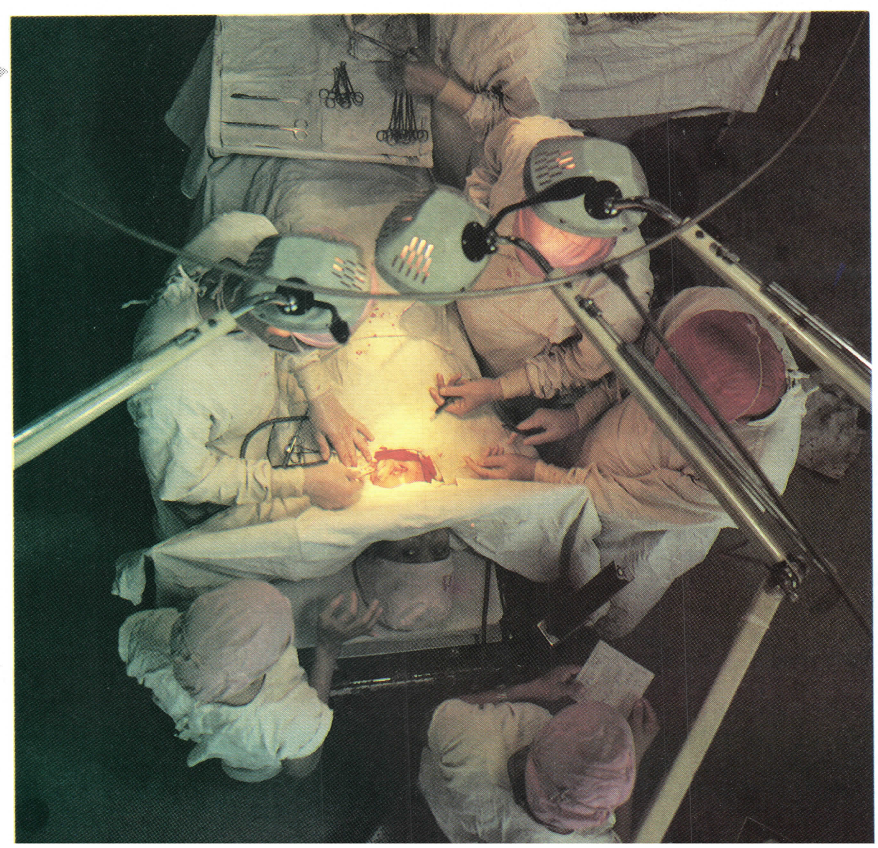
## Hypnotism

Hypnotized subjects are often described as being in a state of 'waking consciousness'. They are highly susceptible to the hypnotist's suggestions and will quite readily take on any role they may be asked to.

While it is easy to hypnotize certain people, it is not quite clear what is happening to them physiologically. So the hypnotic trance is widely regarded as a psychological phenomenon.

Certain people cannot be hypnotized. The most susceptible to hypnosis are children between the ages of eight and 12, who seem to be better at dissociating certain mental capacities from normal consciousness. Hypnotism is used widely in medicine and dentistry and for control of pain and some forms of psychotherapy.

***Wide awake** under the knife, thanks to acupuncture. Needles are used to anaesthetize a patient during thyroid surgery.*



Sally & Richard Greenhill

### Just amazing!

**GET THAT PHONE!**

AFTER WATCHING A HYPNOTIST ON TV, AN ITALIAN BOY FELL INTO A TRANCE. DOCTORS COULDN'T FREE HIS HANDS, WHICH WERE GLUED TOGETHER FOR EIGHT HOURS. ONLY A PHONE CALL FROM THE HYPNOTIST DID THAT.

Paul Raymonde